Technology Review

ENGINEERING
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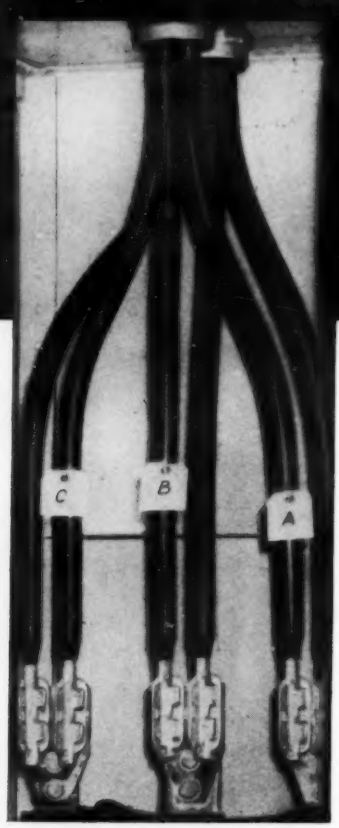
MAY 1960 **Edward D. Stone Discusses Campus Architecture** **Page 27**



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. . . a quiz for Chemical Executives who want to keep posted

QUESTION 1. In 1959, 28 plants in the United States were producing ethylene—the hydrocarbon intermediate which is way ahead of all others both in quantity produced and in versatility. What was the estimated total U. S. capacity for this valuable chemical in 1959?

a — 3.7 Billion Pounds

b — 4.9 Billion Pounds

c — 5.6 Billion Pounds

d — 6.4 Billion Pounds

QUESTION 2. How many of the U. S. ethylene plants were designed, engineered and constructed by the Lummus Company?

	PLANTS	CAPACITY
a	3	.4 Billion lbs.
b	5	.6 Billion lbs.
c	7	.8 Billion lbs.
d	9	1.0 Billion lbs.

ANSWERS: 1. *The answer is (c)—5.6 billion pounds, according to* Chemical Week's *Report on Ethylene, May 9, 1959.*

2. *Again the answer is (c). In the last 10 years Lummus has 7 Ethylene plants to its credit in the U. S. alone with a combined capacity of .8 billion lbs. Lummus' world-wide total is 18, with a combined capacity of over a billion pounds per year. For ethylene projects, or any type of process plant, call on Lummus' 50 years of experience in design, engineering and construction.*

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ELECTROCHEMICAL ENGINEERING, *New Fourth Edition*

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Technology Review

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Volume 62, Number 7 *Edited at the Massachusetts Institute of Technology* *May, 1960*

Feedback

More About Procedures In Mathematics Classes

FROM MALVIN J. MAYER, '33:

Professor Franklin's letter in the March issue was valuable in that it presented sound warnings against any trend to minimize the importance of classical discoveries. It was also of particular interest to me as a parent who has been involved with P.T.A. groups studying new techniques in education.

The phrasing used seems to imply, if not specifically state, that some of the new procedures used for obtaining an early understanding of mathematics *necessitate* a permanent change in language and notation. Perhaps those who have introduced these courses make the same error, but I hope not. The underlying principle, I think, is that algebra is a language. You may have seen the advertisement in the March *Scientific American* quoting Lavoisier on this subject. He said, "Algebra is a real language: Like all languages it has its representative signs, its methods, its grammar—."

If we wish to have students understand that any mathematical notation is simply an expression of a language, then we must give them the deeper understanding that, as in all languages, the same physical object, or even abstract idea, may be expressed in different ways. For example, we may say "Dada," "Daddy," or "Father," but we mean the same thing. . . .

Just as I believe that children in the first, second, and third grades should begin to learn a foreign language so that they may have the deeper uderstanding that our language is merely *one* means of communication among mankind, so I believe that the "new" notation will give a better comprehension of mathematical principles and philosophies at an early age.

While one should not draw generalities from an individual personal experience, some eight years ago in a parent's efforts to provide his child with this better comprehension of the mathematical language, I found that the substitution of squares, triangles, and symbols for *X*, *Y*, and *Z* provided my oldest daughter with a better understanding of algebra. This is particularly true of the square which, by its very form, permits an easy visualization of the building of certain problems. This is not to imply that the square is a substitute for

(*Continued on page 48*)

CURRENT TASTES of Edward D. Stone, '27 who presents "The Case for Modern Architecture on the Campus" (on page 27 this month), are represented by the new medical school and hospital (above) that he designed for Stanford University.

EDITOR: Volta Torrey; BUSINESS MANAGER: R. T. Jope,'28; CIRCULATION MANAGER: D. P. Severance,'38; EDITORIAL ASSOCIATES: J. J. Rowlands, Francis E. Wylie, John I. Mattill; EDITORIAL STAFF: Ruth King, Diana de Filippi, Norma G. Humphries; BUSINESS STAFF: Madeline R. McCormick, Louise E. Ryan; PUBLISHER: H. E. Lobdell,'17.

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This Month

The Cover

A more colorful view of air than the cover picture indicates now intrigues scientists using the Naval Supersonic Laboratory's wind tunnel at M.I.T. How the air flow has been made visible is reported on page 20.

Individuals Noteworthy **4**

Colombian Alumnus receives Great Cross; other news of Alumni.

The Trend of Affairs **17**

Gift to the Institute will provide new housing for women students; Edwin H. Land to be commencement speaker.

M.I.T.'s Humanities Course **21**

Professor Roy Lamson gives a progress report on Course XXI.

Two Experiments in Space **24**

Institute physicists plan searches for solar wind and gamma rays.

Architecture on the Campus **27**

Edward D. Stone, '27, presents the case for modern designs.

Plenty of Room at the Bottom **31**

Richard P. Feynman, '39, talks about amazingly tiny things.

Winter Sports Review **34**

M.I.T. skiers, swimmers, and wrestlers have successful season.

Books **36**

Reviews of two books and listings of others of interest to Alumni.

Institute Yesteryears **52**

Items that were news at M.I.T. 25, 50, and 75 years ago.

Next Month

The Review will report the views of Vannevar Bush, '16, Honorary Chairman of the M.I.T. Corporation, regarding research in space.

Individuals Noteworthy

New Posts

NAMED in the news recently were the Alumni whose elections, promotions, and appointments are recorded below:

Robert J. King, '03, as Chairman of the Trustees, Piedmont College . . . *Ray P. Dinsmore, '14,* as a Director, Goodyear Tire and Rubber Company . . . *Vertrees Young, '16,* as a Life Trustee, Trinity College . . . *James W. Gibson, '20,* as Assistant Treasurer, John Hancock Mutual Life Insurance Company;

Augustus B. Kinzel, '21, and *Cecil Boling, '32,* respectively, as President and as Vice-president, Engineers Joint Council . . . *Henry Flynn, '23,* as General Manager, Refining Department, Texaco, Inc.;

George Y. Anderson, Jr., '24, as a Director, Bucyrus-Erie Co. . . . *John T. Blake, '24,* as Senior Vice-president and a Director, Simplex Wire & Cable Company . . . *Charles A. Thomas, '24,* as Chairman, Monsanto Chemical Company;

Ralph F. Gow, '25, as a Director, United Fruit Company . . . *Daniel J. O'Connell, '29,* as a Trustee, American International College . . . *Hermon H. Scott, '30,* as Chairman of the Board, Institute of High Fidelity Manufacturers;

Herbert L. Wampner, '30, as a Director, Reichhold Chemicals, Inc. . . . *Claude F. Machen, 31,* as a Director, Boston Gas Company . . . *Donald B. Sinclair, '31,* as Executive Vice-president, General Radio Company;

Frederick V. Murphy, Jr., '33, as a Director, Attleboro Electric Company . . . *George S. Trimble, Jr., '36,* and *Albert C. Hall, '37,* as Vice-presidents, respectively, for Advanced Programs and of Engineering, The Martin Company;

Charles M. Edwards, '40, as Assistant General Manager, Bendix Aviation Corporation . . . *David B. Nichinson, '42,* as President, Kollsman Instrument Corporation . . . *Colonel Richard C. Gibson, '42,* as Professor and Head, Department of Astronautics, Air Force Academy;

Neil M. Blair, '47, Vice-president, Intelex Systems, Inc. . . . *Robert S. McClintock, Jr., '48,* as President, National Can Corporation . . . *Albert V. Shortell, Jr., '50,* as Vice-president, Wolf Research and Development Corporation, Boston.

Honors

MEDALISTS and recent recipients of other distinctions include:

Karel J. Bossart, '27, the Sylvanus Albert Reed Award, by the Institute of the Aeronautical Sciences . . . *Lt. Col. Alvah E. Perkins, '30,* the Commendation Medal, by the U. S. Air Force . . . *Franklin K. Pittman, '41,* named as one of the top 10 Career Men in the Federal Government for 1960, by the National Civil Service League;

Elias J. Corey, Jr., '48, and *Charles D. Coryell,* Professor of Chemistry, respectively, the $1,000 Award in Pure Chemistry and the $1,000 Award for Nuclear Applications in Chemistry, by the American Chemical Society;

Astra Zarina-Haner, '55, the Rome Prize Fellowship in Architecture, by the American Academy in Rome . . . *Peter S. Eagleson, '56,* the Desmond Fitzgerald Medal, by the Boston Society of Civil Engineers . . . *Egon Orowan,* Professor of Mechanical Engineering, the Bingham Medal Award, by the Society of Rheology.

Faculty Notes

KURT S. LION, Associate Professor of Applied Biophysics, will attend the fifth international Instruments and Measurements Conference, at the Royal Institute of Technology in Stockholm next September. The meeting is being sponsored by the Royal Swedish Academy of Engineering Sciences and the Swedish Association of Technical Physicists.

Virgilio Barco-Vargas, '43, Minister of Public Works of Colombia, receiving the Great Cross of the Order of Vasco Nuñez de Balboa from Victor C. Urrutia, Minister of Public Works of Panama. Dr. Vargas also recently was awarded the Great Cross of the National Order of Merit by Ecuador.

Jerome B. Wiesner, Acting Head of the Department of Electrical Engineering, and Jerrold R. Zacharias, Professor of Physics, will participate in an international conference on Science in the Advancement of New States at the Weizmann Institute of Science in Israel next August.

James M. Austin, '41, Associate Professor of Meteorology, Dr. Pauline M. Austin, '42, and others from M.I.T. participated in the Weather Radar Conference in San Francisco in April.

Attorney from Alaska

A SLOAN FELLOW now in the M.I.T. School of Industrial Management, Howard W. Pollock, of Anchorage, Alaska, has been admitted to practice before the U. S. Supreme Court.

Mr. Pollock is a disabled veteran of World War II, who went to Anchorage from New Orleans in 1947. He was chairman of the statehood committee in the territorial legislature, and was named as one of the nation's outstanding young men in 1955.

(Continued on page 6)

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Individuals Noteworthy

(Continued from page 4)

James Murray: 1902-1960

THE DEPARTMENT of Civil and Sanitary Engineering lost James A. Murray, Associate Professor of Materials, when he died on March 5 after an operation.

Professor Murray was born in Cambridge on August 23, 1902, and was graduated from Harvard University in 1924. In 1926 he joined the staff of the National Bureau of Standards and was chief of the Lime and Gypsum Section, before becoming associated with the Warner Company of Philadelphia in 1930 as Director of Research. He joined the M.I.T. Faculty in 1948 to take charge of research on cementitious materials and masonry units. He was chairman of the committee on lime for the American Society for Testing Materials and a member of the American Institute of Chemical Engineers and the American Chemical Society. An active Mason, he was Past Master of Thompson Lodge in Malvern, Pa., and Past High Priest of the Montgomery Chapter, RA-262, in Ardmore, Pa.

Surviving him are his wife, Mrs. Rhoda Jelley Murray; two children, Donald W. and Judith L. Murray, and three brothers, Stanley S. and William K. Murray of Lexington and Allan F. Murray of Bedford.

Liaison Officer

RICHARD B. FINN, JR., '54, became an Industrial Liaison Officer for M.I.T. on March 1. Mr. Finn joined the Electrical Research Department of the American Electric Power Service Corporation when graduated from Course VI-A, and later went to the Oak Ridge School of Reactor Technology and worked with the Nuclear Power Study Group of Commonwealth Edison Company and the East Central Nuclear Group of American Electric Power Service Corporation. He participated in these assignments in the preliminary design, development, and pre-operational testing of power reactors for the public utility industry. He was also joint author of a paper presented before the American Institute of Electrical Engineers in 1957.

(Concluded on page 12)

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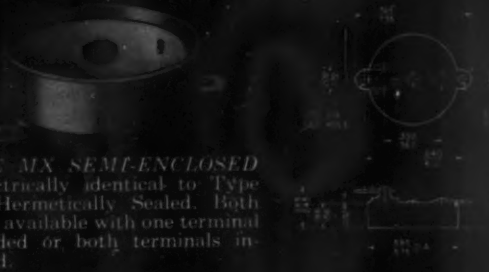

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Four such vessels are shown here: three new tankers, and the beautiful new liner Rotterdam, pride of the Netherlands. Boilers for one – S.S. Faith – were fabricated in C-E shops in Chattanooga, Tennessee, and shipped to Taiwan for installation. Boilers for the others were built overseas – in Holland, Japan and Norway – by C-E licensees.

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S.S. KOLL—A 36,000 deadweight ton tanker built by Eriksberg Mek. Verkstad of Sweden for Odd Berg of Norway. Boilers built by C-E licensee, A/S Kvaerner Brug, in Norway.

S.S. FAITH—A 36,000 deadweight ton tanker built by Ingalls-Taiwan Shipbuilding and Dry Dock Co. of Taiwan for the General Tanker Corporation, U.S.A. Boilers built by Combustion Engineering, Inc., in the U.S.A.

S.S. VEEDOL—A 46,000 deadweight ton tanker built by Mitsubishi Shipbuilding & Engineering Co. of Japan for Tidewater Oil Co., U.S.A. Boilers were built by C-E licensee, Mitsubishi Shipbuilding & Engineering Co., in Japan.

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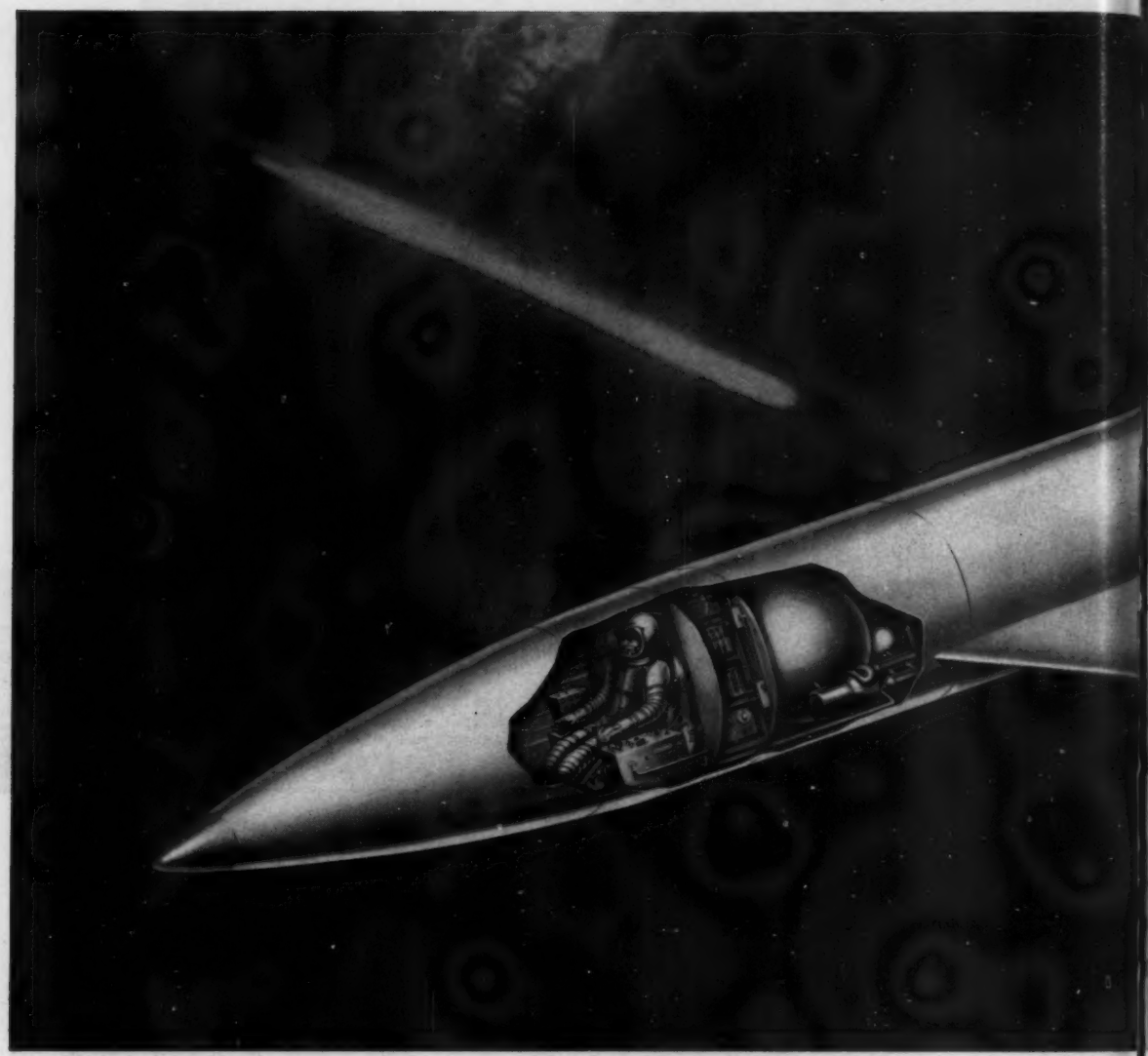

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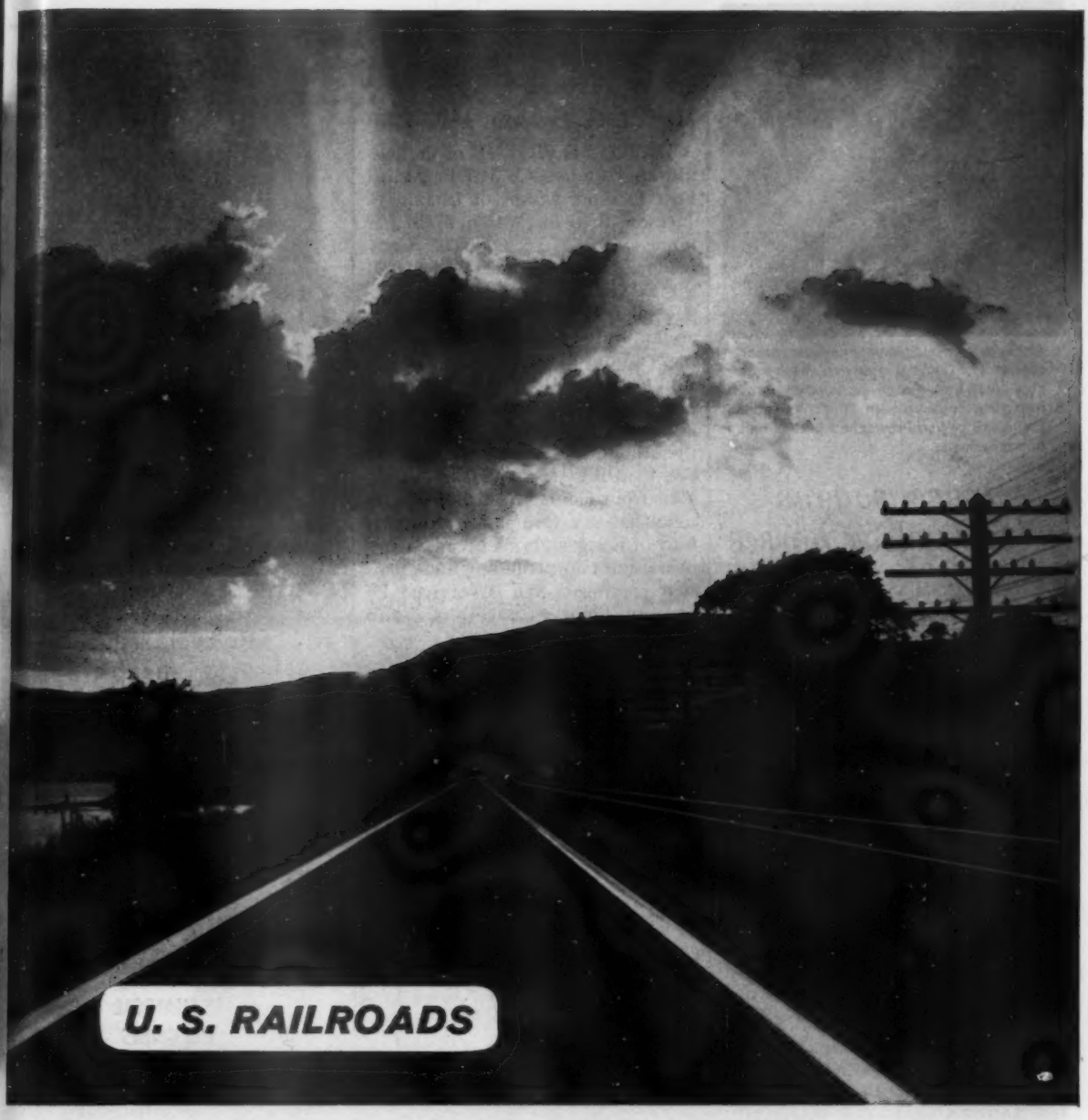

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Arthur E. Raymond, Senior Engineering Vice President of Douglas, goes over new space objectives that will be made possible by nuclear propulsion with Elmer Wheaton, Engineering Vice President, Missiles and Space Systems.

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Individuals Noteworthy

(Concluded from page 6)

Mrs. D. C. Jackson: 1867-1960

A DEVOTED FRIEND of the Faculty and students of M.I.T., Mabel Foss Jackson, widow of Dugald C. Jackson, died on March 27 in her home at 5 Mercer Circle, Cambridge. Her husband was head of the Department of Electrical Engineering for 28 years and was elected an honorary member of the Alumni Association in 1939. A native of Maine, who attended Penn State, Mrs. Jackson made her home a place of friendship and counsel for the students, Alumni, and staff of the Institute. Her son was graduated from Course VIA, her daughter married a Course VI graduate, four of her grandsons became engineers, and two granddaughters married engineers. She is survived by her son, eight grandchildren, and 17 great grandchildren.

Charles Bumer: 1897-1960

THE CHAIRMAN of the Mathematics Department at Clark University, Charles T. Bumer, died on March 14. He was a staff member of the Radiation Laboratory at M.I.T., and a staff consultant of the M.I.T. Instrumentation Laboratory, before going to Clark in 1948.

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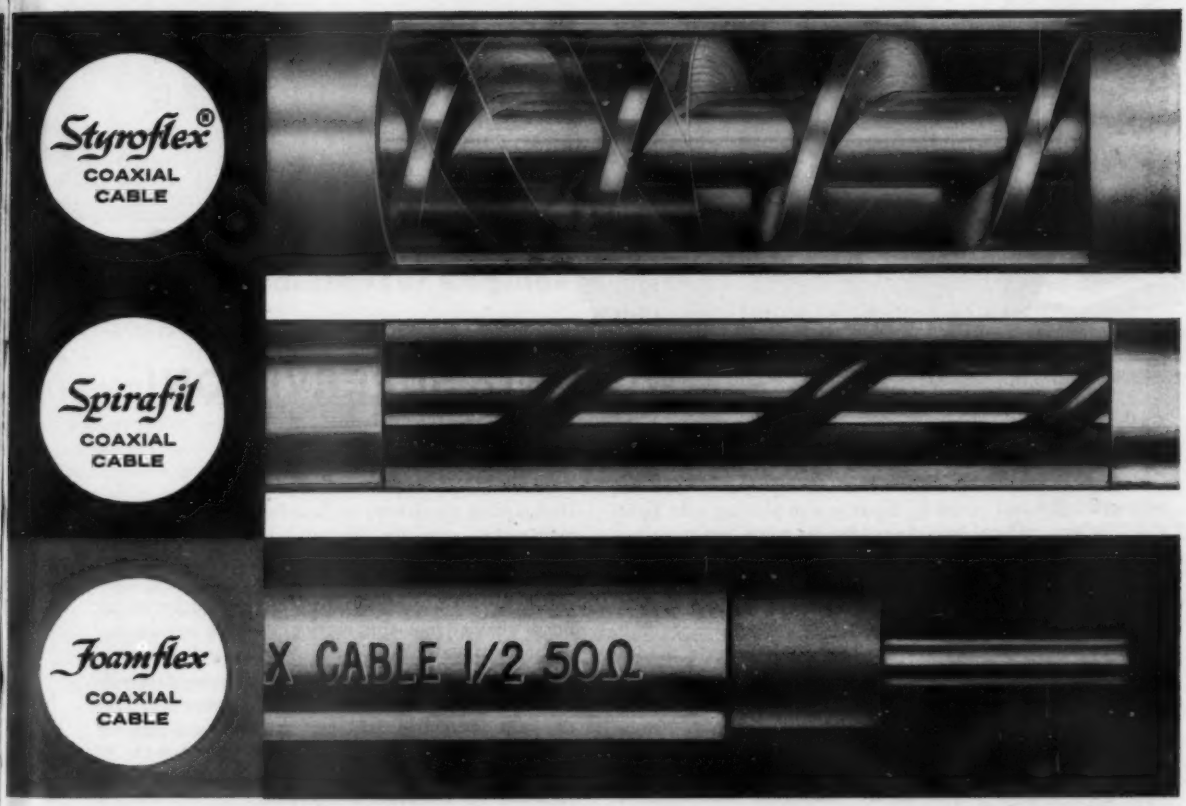

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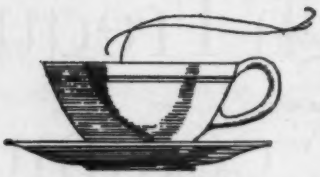

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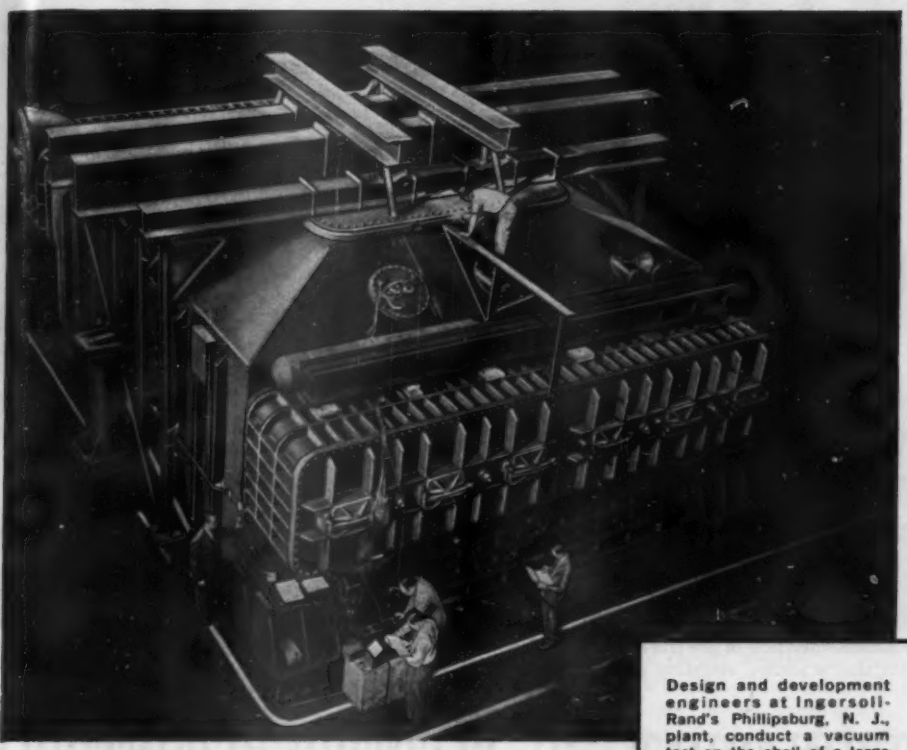

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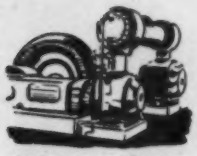

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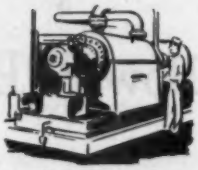

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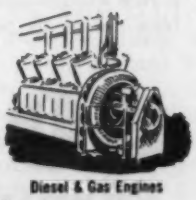

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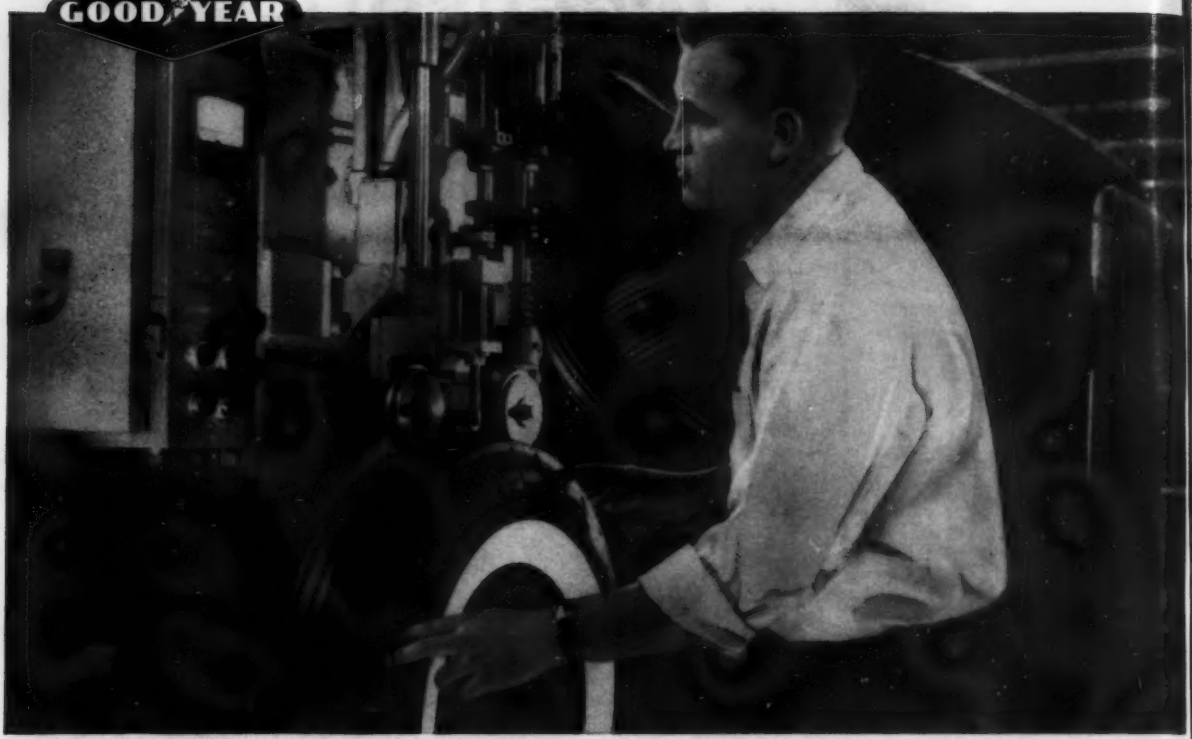

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Trend Of Affairs

M.I.T. Receives Pledge For Women's Dormitory

THANKS to an anonymous pledge of $1,500,000, President Julius A. Stratton, '23, announced in April, M.I.T. soon will have an on-campus dormitory to accommodate from 120 to 150 women students. It will be built on a site facing the Charles River close to the Chapel and the Kresge Auditorium.

The Institute has admitted women almost since it was founded, but they always have been outnumbered greatly by the men. Of 6,200 students now, 155 are women. Institute housing is available for less than a third of these women, and some of this housing is on the Boston side of the Charles at a considerable distance from the school.

"The enrollment of freshman girls at M.I.T.," Dr. Stratton said, "has been necessarily limited to the accommodations available under the direct supervision of the Institute. Yet there has been a steady rise in the number of highly qualified women applicants at M.I.T. over the last several years. Happily, the timely and generous dormitory pledge which the Institute has now received will remove some of the limitations on the enrollment of women and on the kind of extracurricular program we can provide for them.

"Women have made substantial contributions to scientific and technical progress in the past and today there are more opportunities for girls in the scientific professions than ever before. Indeed, women's potential for achievements in these fields represents one of the great underdeveloped resources of the country.

"M.I.T. believes that a strong residential program, designed to enhance the education of students, is a sound objective. This magnificent pledge to the Institute now affords us an unprecedented opportunity to meet this objective for our women students and to improve their residential and social environment. It is a means also to advance the professional development of our women students."

The first M.I.T. coed was Ellen H. Swallow, '73, who became the wife of Professor Robert H. Richards, '68, served as lecturer in chemistry at the Institute, and won international renown as an authority on food and sanitary chemistry. A survey a few years ago indicated that a woman who has studied at M.I.T. is likely to be a scientist, married to a scientist, to belong to professional societies, and to be active in community affairs.

The Commencement Exercises

THE INSTITUTE'S 1960 commencement address will be given by Edwin H. Land, Institute Professor (Visiting) and President of the Polaroid Corporation. The exercises are to be at 10:30 A.M. on Friday, June 10, in the Rockwell Cage, and the graduates and their families will be greeted afterwards at the President's luncheon, to be held in the Great Court if weather permits. The baccalaureate service for the Class of 1960, preceding the commencement exercises, will be at 3 P.M. on Thursday, June 9. Huston Smith, Professor of Philosophy, will speak at this service.

Dr. Land, the commencement speaker, was the first fellow appointed to the School for Advanced Study at M.I.T. He is the inventor of the Land camera and his recent studies of color vision have been widely acclaimed. The list of honors which have been bestowed on Dr. Land is long: It includes the Hood and Progress Medals of the Royal Photographic Society, the Cresson and Potts Medals of the Franklin Institute, the Holly Medal of the American Society of Mechanical Engineers, the National Modern Pioneer Award of the National Association of Manufacturers, the Rumford Medal of the American Academy of Arts and Sciences, the Duddell Medal of the Physical Society of Great Britain, the Progress Medal of the Society of Photographic Engineers, and the F. W. Brehm Memorial Lecture Medal. He also has received honorary degrees from Tufts, the Polytechnic Institute of Brooklyn, Bates, Colby, Harvard, and Northeastern.

Dr. Land was president of the American Academy of Arts and Sciences in 1951-1953, and is a member of the National Academy of Sciences; a fellow of the Royal Photographic Society of Great Britain, the Royal Microscopical Society, and the Optical Society of America; and a member of the Advisory Board of the Hoover Institute and Library.

The Alumni Day Program

MONDAY, June 13, will be Alumni Day at M.I.T. In the forenoon, Alumni will have a chance to visit and inspect departmental facilities. At the Alumni Day Luncheon in the Great Court, President Stratton will speak about the past year and the future of the Institute. A symposium on communications and the life sciences will be held in the afternoon, and a cocktail party on Briggs Field will precede the Alumni Banquet. A ballet performance with a 40-piece orchestra will be given in the auditorium after the banquet.

Molecular Biology

THE STUDY of collagen is approaching a third stage, in which the chances of discovering clinical applications of the findings to the problem of aging and the treatment of degenerative diseases are likely to be greater, Institute Professor Francis O. Schmitt recently told the post-doctoral fellows in the M.I.T. School for Advanced Study.

First, the internal organization of this marvelous and essential tissue had to be learned. Its molecules now have been isolated, seen under the electron microscope, taken apart, and reversibly recombined and characterized physico-chemically. The second stage of this work, in which Dr. Schmitt has been a leader for many years, has involved the study of interactions between these molecules. Now the subtle, positive and negative feed-back control mechanisms, which seemingly enable them to unite automatically — like bricks capable of laying themselves in appropriate patterns — at the right times and places in the body are being sought.

Collagen consists of long macromolecules, containing helically coiled polypeptide chains, which normally connect themselves at their ends to form fibers. Now, in the third stage of a long and difficult research program, the researchers who have learned this are looking for the enzymes and cofactors which regulate fibrogenesis and are trying to explain the processes by which the growth of collagen is directed.

Knowledge acquired and techniques devised in a wide range of academic disciplines are needed in this as in the earlier efforts to understand molecular biology. It is a research field, Dr. Schmitt reported, in which scientists of other countries are very energetic — and also one which M.I.T. is in a fortunate position to exploit.

Seven of the men on the roster of the School for Advanced Study this year are Sloan Foreign Postdoctoral Fellows. Professor Schmitt spoke at one of a series of dinners arranged for the men in this School by its director, Institute Professor Martin J. Buerger, '24. At previous dinners, they have heard Professor I. Fankuchen of the Department of Physics at the Brooklyn Polytechnic Institute discuss crystallography and Professor Patrick M. Hurley, '40 speak on the growth of radiogenic nuclides and early earth history.

Tracking Pioneer V

WHEN A Thor-Able rocket rose from Cape Canaveral at 0800 on March 11, a world-wide network of tracking stations went into instant operation to flash the news of Pioneer V, the most distinguished of U. S. deep space probes to date. As usual, Lincoln Laboratory's Millstone Hill station was in the vanguard, operating in this instance not as a two-way radar but as a radio telescope, to receive radio signals sent out from the space vehicle. Over-all direction of the whole launching and tracking operation was in charge of the National Aeronautics and Space Administration, and Space Technology Laboratories in Los Angeles was the nerve center of the network.

First to acquire the target, transmitting loud and clear, was an NASA Minitrack station at Blossom Point, Md. Seconds later, at 0805, earth's newest offspring rose over Millstone's horizon, right on schedule and almost exactly on the predicted course. Millstone tracked the transmitter as it passed out of sight from Cape Canaveral at 0812 and heard it picked up by Jodrell Bank in England at 0815. Meanwhile, data were being transmitted in real time, just as they were received, from Millstone to STL, providing the earliest assurance that all was going well. Five more transmissions were observed successfully that day, before the probe set over Millstone's horizon. The tracking crew then suspended operations and left subsequent communications in the hands of the three stations (at Hawaii, Jodrell Bank, and Goldstone, Calif.) which turn the radio on and off by remote control. The probe was on its way, and there was satisfaction and pride in playing a key role in such a significant and successful step deeper into space.

THIS "FLYING DUTCHMAN" is one of about 50 pieces of wire sculpture produced by Professor C. Fayette Taylor, '29, of the M.I.T. Department of Mechanical Engineering. Its gold-plated brass rods are silver-soldered together. It will be exhibited at the Rockport Art Festival this summer.

Lindgren Memorial Fund

FORMER STUDENTS and colleagues of Waldemar Lindgren are establishing a fund in his memory to be used for scholarship aid, to support student thesis research, and to build up a collection of books regarding his life and works. Professor Lindgren came to M.I.T. on a full-time appointment in 1912, and served for many years as William Barton Rogers Professor of Economic Geology and head of the Department of Geology.

Former President Herbert Hoover, who assisted him during college summer vacations beginning in 1893, has written that: "Dr. Lindgren's work contributed enormously not only to science but also to the discovery and development of our natural resources. . . . It is fitting that his memory should be marked by a scholarship at M.I.T. I will be glad to contribute."

New Alloys Suggest Greater Uses of Ice

ICE AND SNOW are "the most plentiful and so far the least useful" substances on earth. Can they be used as large-scale building materials in some parts of the world? As found in nature they seldom have the properties required for modern construction. But in Building 20, the birthplace of many innovations, M.I.T. now has an Ice Research Laboratory. Here, in a test chamber that can be kept at 40 degrees below zero, a group of parka-clad researchers headed by W. David Kingery, '48, Associate Professor of Ceramics in the Department of Metallurgy, is studying ways of improving ice. In a few years, Dr. Kingery believes, engineers will be using ice and snow as construction materials, as a result of this and other research in "applied glaciology."

"The basis for the new studies," he explains, "is that 10 per cent of the earth's surface is covered by ice and snow. The snow-covered areas and the oceans are the two great terrestrial frontiers which have not been fully explored; in some minds they offer much more hope for exploitation than does outer space. But development of the earth's cold regions can only be achieved when the local environment, including ice and snow, is positively used rather than passively fought.

"Ice and snow have been used as construction materials by residents of cold climates for a long time. Applications have included snow houses, ice logging roads, ice bridges, and ice storage areas. In all these, however, the requirements as to structural properties are not stringent, and the applications have been limited to the use of natural, unimproved material. Extensive progress also has been made in the excavation of tunnels and rooms in glacial ice and snow, particularly by the U.S. Army Snow, Ice, and Permafrost Research Establishment. But the opportunities and usefulness for this kind of construction are obviously limited."

The research now under way is aimed toward the development of processing methods which will permit much more than "stone age" activity. By solidification, mining, and comminution (pulverizing) of natural ice and snow, the incorporation of strengthening agents, and new costruction methods, stronger and more useful ice structures may be made possible.

The M.I.T. Ice Research Laboratory has grown out of studies in which Dr. Kingery has been engaged for the Arctic Institute of North America. This winter he spent three weeks supervising its field program at Point Barrow, Alaska, where the use of alcohol and other lubricating agents to enable ice grains to form dense structures is being studied.

Ice alloys, he reports, appear to be one of the most promising avenues of research, but studies of them have been limited. When the British, during World War II, considered building a 2,000,000-ton aircraft carrier out of ice, it was found that the addition of about 15 per cent of sawdust more than tripled the tensile strength of ice. Other alloys have since been developed. Ice that contains as little as 4 per cent by volume of Fiberglas, Dr. Kingery says, has been found to be 10 times stronger than natural ice; this alloy, in other words, has a tensile strength of 2,000 pounds per square inch, whereas that of natural ice is only 200 pounds per square inch.

A stick of ice will hold a 40-pound weight – if you add a small amount of Fiberglas to it. Demonstrating this is W. David Kingery, '48, in the M.I.T. Ice Research Laboratory. Alloys of ice, Professor Kingery believes, may increase its usefulness as construction material.

To land modern aircraft now, thicknesses of 50 inches of fresh ice, and up to 74 inches of sea ice, are regarded as necessary in some cases. Development of new ice alloys could substantially reduce these requirements for safe landing places.

The M.I.T. laboratory, which is equipped to measure ice strength, study stresses, and determine solidification characteristics, is sponsored by the Air Force Cambridge Research Center (AFCRC). It co-operates with the Arctic Research Laboratory at Point Barrow, the Climatic Laboratory at Eglin Air Force Base, Eglin, Fla.; and the Ellesmere Ice Shelf Project of the AFCRC.

Professor Kingery has been a pioneer in the development of physical ceramics and is widely known as an authority on high-temperature technology. His associates in these new studies include: Clyde M. Adams, Jr., '49, Associate Professor of Metallurgy; Nicholas J. Grant, '44, Professor of Metallurgy; and Philip L. deBruyn, '52, Associate Professor of Mineral Engineering.

Impressions of the World

AT THE Alumni Council's March meeting, James R. Killian, Jr., '26, described his recent trip around the world.

In London, Dr. Killian addressed a luncheon of the Scientific and Parliamentary Committee, attended by 400 persons, including 170 Members of Parliament, and found himself wishing afterwards that the United States had a counterpart of this committee.

In India, he visited the M.I.T. office and observed firsthand the work of the Center for International Studies and the Indian program of the Ford Foundation. Here, as everywhere else, he saw abundant evidence of the activities of Alumni.

In Australia, he observed some of the "extraordinarily effective" work of the CSIRO (Commonwealth Scientific and Industrial Research Organization), and visited four universities.

In Istanbul, Beirut, and the many other cities where he stopped briefly, he was impressed both by the impact of M.I.T. on the world and the growing interest in scientific and technological education.

His total flying time was 62 hours and 40 minutes, and his average speed aloft 406.3 miles per hour, and the only major delay occurred on the New York-to-Boston leg of the trip.

Edward J. Hanley, '24, President of the Alumni Association, presided and Clarence L. A. Wynd, '27, nominee for the Association's presidency, was among the guests whom Mr. Hanley introduced.

Patience and Persistence

ONE OF 15 studies for the Senate Committee on Foreign Relations by private research organizations and institutions was completed this spring by the M.I.T. Center for International Studies. It dealt with economic, social, and political change in the underdeveloped countries, and its implications for U.S. policy.

Senator J. W. Fulbright, chairman of the committee, released it to the press with the observation that it points out quite clearly the forces which must be fully understood to make foreign policy serve our nation, and "stresses the importance of utilizing the economic instruments which we have available for the purpose of bringing about orderly transitions in the underdeveloped societies."

Excerpts to which he called particular attention included recommendations that American policy "be characterized by a patience and persistence which have not always been its trade-mark."

Seeing the Air Rush By

AT THE M.I.T. Naval Supersonic Laboratory, where hypersonic velocities now have been achieved, a new technique has been developed for making the airflow in the vicinity of a model placed in the tunnel visible to the naked eye.

For years wind tunnel operators have used schlieren systems for this purpose, but at the extremely low pressures and densities associated with hypersonic flow there are not enough air molecules for good schlieren observations. The new NSL technique places two negatively charged probes in the air stream, a trifle closer to the model than to any other part of the tunnel, all of which is a positive electrical ground. As the voltage is increased to around 1,100 volts in these probes, there is a reaction with the excited hypersonic air in the tunnel and the flow patterns become visible in strange, brilliant oranges and blues. The mechanism that produces these effects it not yet clearly understood. This mechanism, nevertheless, makes flow phenomena visible that had been postulated theoretically although never verified experimentally before.

A COMPUTER with a density of 56,000 components per cubic foot won honors for Eldon C. Hall, '53, an engineer in the M.I.T. Instrumentation Laboratory, and Samuel A. Francis, '49, at a Miniaturization Award dinner in New York this spring. Pictured here is one of the 54 modules of the complete miniature digital computer that they developed for a control application. It is only one-fourth the size and one-half the weight of previous comparable computers, and has led to major changes in the design and objectives of an important weapon system program.

(THE TREND OF AFFAIRS *is concluded on page 42*)

M.I.T.'s Humanities Course

It offers students an exciting and exacting opportunity to relate professional knowledge to their society's culture

BY ROY LAMSON

ROY LAMSON, Professor of Literature at M.I.T., attended Cambridge High and Latin School and received his A.B., A.M., and Ph.D. from Harvard, where he was an instructor for three years. He came to M.I.T. from Williams College, where he was Professor of English and Dean of Freshmen. He was in the War Department's Public Relations Bureau and Historical Division during World War II, and was historian of Supreme Headquarters Allied Powers in Europe.

At a social gathering in Boston when I came to M.I.T. in 1957, I was asked what I was teaching.

"English," was the reply.

"I'm glad," said the questioner, "that those scientists and engineers are learning to speak and write."

His attitude betrayed a too common misunderstanding of the Institute. The subjects taught in liberal arts colleges never have been disdained here, and the alleged "illiteracy" of science and engineering students is a myth. Instruction in the humanities and social sciences has been given at M.I.T. for many years, and today one-fifth of every student's time is devoted to the study of literature, history, philosophy, music, visual arts, or the social sciences. This is a requirement amounting to the equivalent of at least one subject in the School of Humanities and Social Science (one of M.I.T.'s five schools) each semester for four years.

The reason for the requirement is not that a student shall have a little frosting to his scientific or technological cake but that he have some serious start in relating his knowledge of science and engineering to the problems of life in the past, the present, and, indeed, the future. It asks that every student look at the meaning of his professional study through other disciplines, through the arts, through history and philosophy, and through the social sciences.

In social studies, and especially economics, M.I.T. has a strong tradition. Some 13 years ago, Course XIV was developed to enable M.I.T. students to combine basic training in engineering or science with the social sciences. To carry out this program today, the Department of Economics and Social Science, which has sections for economics, political science, industrial relations, and psychology, offers courses leading to the B.S. in Economics, Politics, and Engineering (XIV-A) and in Economics, Politics, and Science (XIV-B), and to master's and doctor's degrees in these fields.

The Origin of the Course

A few years ago the Institute went even further in providing opportunities for study of the humanities by introducing a new program leading to bachelor's degrees in Humanities and Science or in Humanities and Engineering. Seventy students now are enrolled in this program, known within the Institute as Course XXI.

The reasons given by the Committee on Undergraduate Policy for establishing this course were:

1) The increasing social and industrial responsibilities of technically trained men.

2) The increasing number of M.I.T. graduates whose careers soon lead them away from strictly technical or scientific activities to administrative and executive responsibilities.

3) The increasing recognition — here and elsewhere — of the need for a broad education at the undergraduate level for prospective specialists as well as nonspecialists.

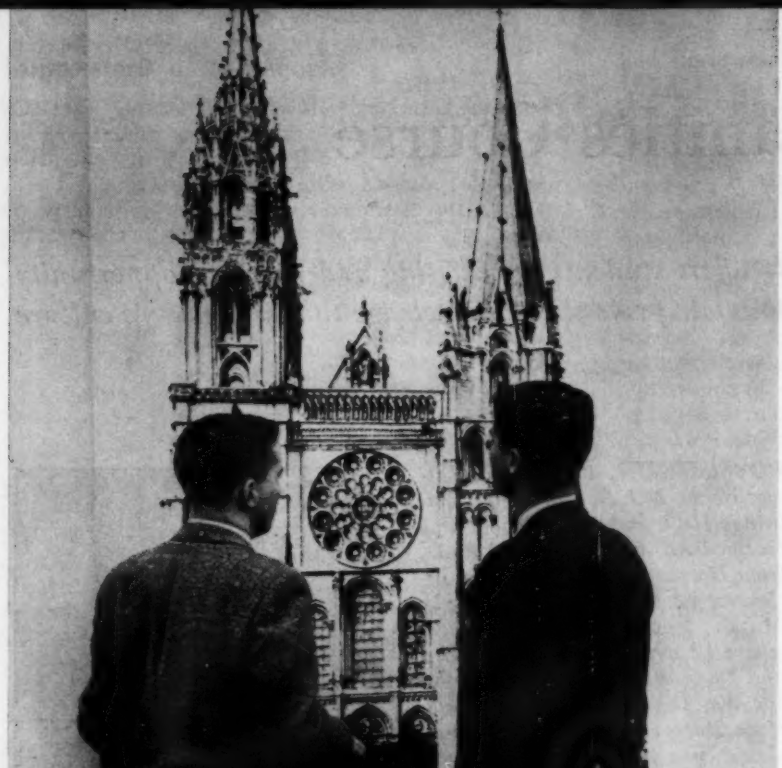
4) The desirability of experimenting on a small scale with a new type of engineering and scientific education to provide "the broad foundation of liberal study which is already demanded of the doctor and lawyer and should be demanded of the engineer."

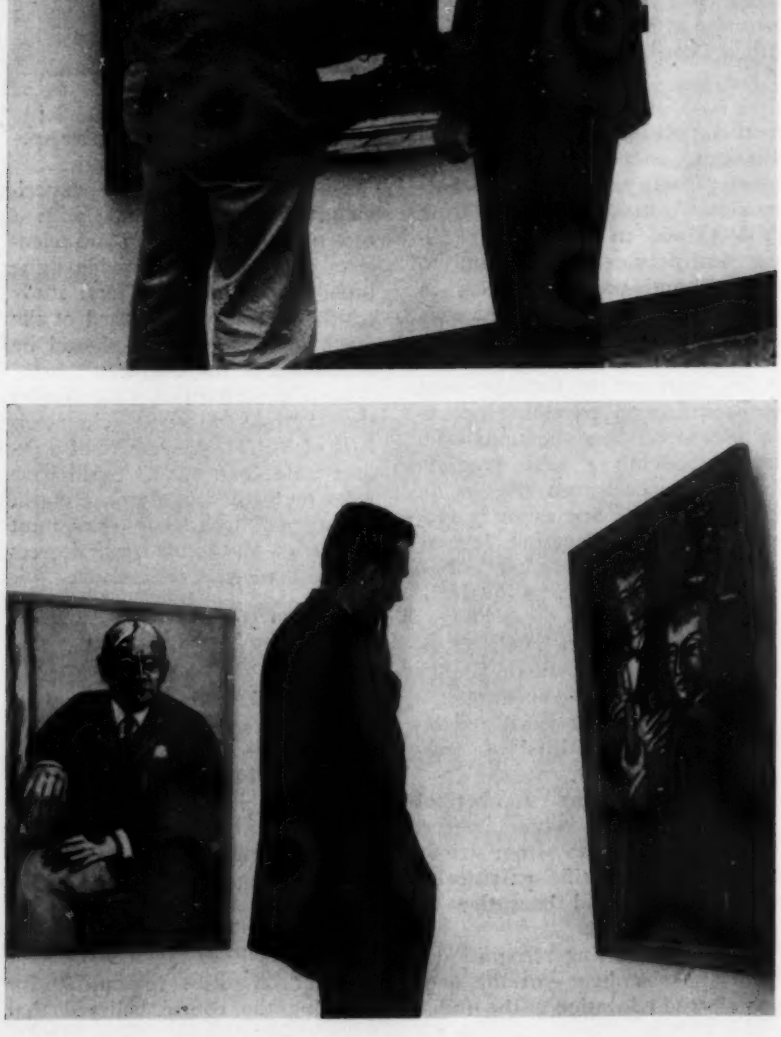
5) The conviction that under the rigorous standards characteristic of M.I.T., the holder of a degree from Course XXI could have a far more thorough grounding in science and technology than most students with baccalaureate degrees from liberal arts colleges.

Two Areas of Knowledge

Course XXI allows students to spend about half their time in a professional field — physics, chemistry, mathematics, or electrical engineering, for instance — and the rest in the humanities. The curriculum, with its strong emphasis on two areas of knowledge, is a double major, giving students an effective way to bring their interests in the humanities and in their chosen fields of science or engineering together.

The committee responsible for creating the course believed that





such a grounding has a large, perhaps indispensable, meaning for many men involved in decision-making in our industrial society. Viewed simply as a terminal course of study such a curriculum should provide an admirable preparation for nonprofessional life. At the same time, it should be excellent for those intending to study medicine, law, education, business or public administration, and for graduate work in several fields of the humanities. Its relation to graduate work in science and engineering goes without saying.

Students in the first two years of the new course follow the regular M.I.T. curriculum in physics, mathematics, chemistry, and the required "core" course *Introduction to the Humanities*, an amalgam of literature, history, and philosophy, in which one studies Greece, the Middle Ages, and the Renaissance in the first year, and the Enlightenment and the Nineteenth Century in the second year. Given their choice in their junior and senior years of choosing a program in philosophy and literature or in American industrial society, the first class of sophomores surprised the staff by choosing the philosophy and literature option, eight to one.

A Liberal Choice

But there is no typical program in Course XXI. Because of its flexibility, it offers a wide variety of combinations of study including science, engineering, philosophy, history, literature, visual arts, music, psychology, and the social sciences. The full value of this program must be seen by the student through an understanding of his own aims, with the help of his teachers and advisers.

If he wishes, a student may continue his work at M.I.T. a fifth year, and such a program will lead to a degree in his chosen scientific or engineering profession — either a second bachelor of science or, in some cases, a master of science.

The choice both within a sequence and in other elective subjects in humanities is liberal since the Department of Humanities offers more than 60 subjects in history, philosophy, literature, and music, taught by a distinguished Faculty. A student may elect sub-

jects in several areas of learning, such as literary criticism, the Bible, Shakespeare, the modern novel, American foreign policy, the Russian revolution, classical philosophy, metaphysics, the philosophy of science, symbolic logic, Twentieth Century music, or the string quartets of Beethoven. For properly qualified students, special study, either individual or in small groups, is available. In the Department of Modern Languages the student may choose to study French, German, or Russian — both language and literature — or topics closely associated with modern scientific methods in linguistics. Through the Department of Economics and Social Science, he may elect a variety of subjects in economics, political science, international relations, and psychology.

In his senior year each student participates in a humanities seminar in which he prepares through discussion and exercises for a thesis which can encompass his work in both science and the humanities. The senior may also pursue in the thesis any special, important line of interest he may have developed in the humanities. For this thesis the work is independent study under one or more Faculty supervisors chosen from the Institute, and it takes about one-third of the time of the senior year. It is equivalent to the honors program or tutorial or preceptorial in leading universities. For many students the senior thesis has been one of the most important experiences at M.I.T.

In subject matter and in breadth and depth of study, in fact, these theses have offered every Course XXI student an exacting intellectual experience. Subjects for theses have included:

A History of Quantum Physics.

The Influence of Newton on Literary Criticism in the Seventeenth Century.

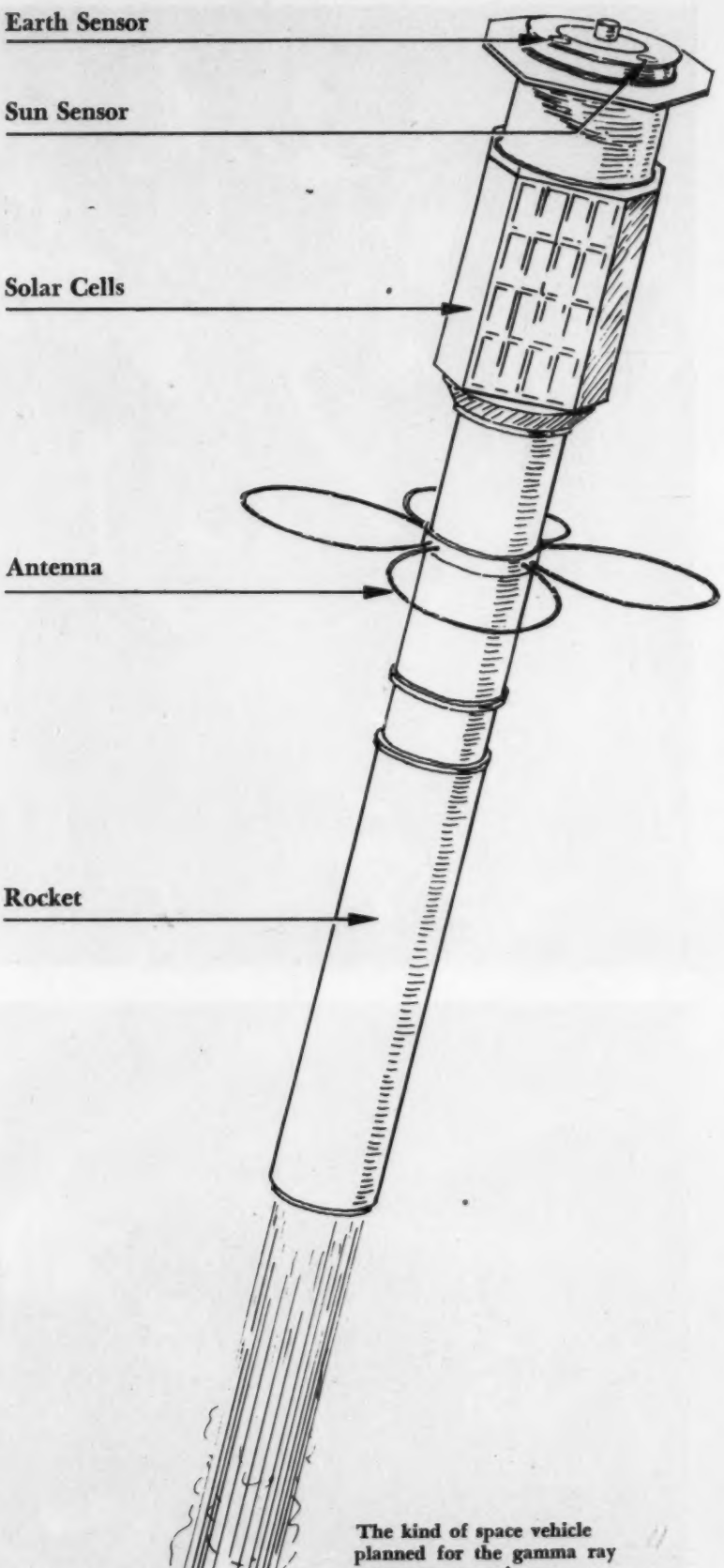
The Coalescence of Soap Bubbles (both a historical study and an experiment).

Shakespeare's Tempest *in the Seventeenth Century: The Impact of Scientific Thought.*

The Characteristics of Tense in the English Language.

Mechanical Translation of Chinese.

(Concluded on page 50)



The kind of space vehicle planned for the gamma ray astronomy experiment.

Two M.I.T. experiments are scheduled to be carried into space within a year in satellites which the National Aeronautics and Space Administration hopes to launch. One will be part of a search for a solar wind; the other part of a search for faint beams of gamma rays. The solar wind, if found, might help explain complex events within the solar system; the gamma ray beams, if found, might improve our mental picture of the Milky Way and other great galaxies of stars.

These experiments are not related, but both have been conceived in the Laboratory for Nuclear Science, both are efforts to grasp new opportunities created by the availability of great rockets and sophisticated instruments, and both are remindful of the experiment that Benjamin Franklin performed by flying a kite into a storm.

Since these are attempts to measure effects about which little is known, it will not be surprising if the apparatus has to be modified and the work repeated before significant data are obtained. To look for the solar wind, a new version of an old instrument has been designed; to look for the gamma ray beams, a new kind of telescope is being produced.

Both instruments, moreover, are expected to operate in difficult-to-attain environments: The solar wind will be sought throughout the region between the earth and the moon, and the gamma ray data in the shallower region between the earth and its newly discovered radiation belts. Putting vehicles into the required orbits, measuring phenomena which may be surprising, and getting the findings back to

Two M.I.T. Experiments in Space

Searches are planned for a solar wind and for gamma rays which might clarify our mental picture of the universe

earth, are certain to be difficult feats – but even failures may be enlightening.

The Solar Wind

Michael Faraday's scientific career has been likened to walking through a marvelous, unexplored forest "and stopping from time to time to lift up from the ground a dazzling flower or a brilliant jewel." A modern version of an instrument that bears his name, the Faraday Cup, will be used to try to find the density, the velocity, and the directional movement of the ionized particles that are believed to constitute a solar wind. This cup will be basically a collector plate, a few inches in diameter, beneath a series of grids. It is scheduled to be sent into a jungle that right now is as bewildering as the forest which Faraday trod.

Since charged particles as well as light from the sun reach our atmosphere, the sun's atmosphere is thought of now as a plasma that extends far out from the sun's apparent surface – so far out, in fact, that the earth and moon really are within this huge blob of plasma. At times solar flares seem to send out long tongues that do not reach the earth until hours after the disturbances to which they are ascribed have been observed by other means. There also is reason to believe now that streams of particles leave the sun almost continuously, but varying greatly in energy. This wind may both sway and be swayed by magnetic fields in space.

Compared to the earth's magnetic field, the magnetic phenomena rooted in the sun seem fantastic. Lines of force associated with solar disturbances are intermingled with the sun's general field – and the latter not only varies in intensity and distribution but also sometimes reverses its polarity. Particles leaving the sun may be tossed about and accelerated by these complex magnetic forces; and the particles themselves, in turn, may stretch out magnetic lines of force as if they were rubber bands.

The main part of the payload of the space vehicle to which the M.I.T. solar wind experiment has been assigned will be a group of magnetometers provided by the Goddard Space Flight Center. While they measure magnetic fields, if all goes well, the Faraday Cup will measure the particle flow.

Data regarding these related matters are being sought now for at least three reasons:

1) Interactions between the plasma that constitutes the sun's atmosphere and our planet's own atmosphere are important factors in meteorological phenomena, auroral displays, geomagnetic storms, and radiation belts. Hence, they interest weathermen, communication engineers, and prospective space travelers as well as physicists.

2) Since the electromagnetic processes in space are on a scale that cannot be duplicated on the earth's surface, observations of them may result in advances in magnetohydrodynamics. Such advances are needed in efforts to control and exploit thermonuclear reactions.

3) More certainty about what happens within our solar system would be helpful to the astronomers striving to envisage the wonders elsewhere in the universe and might contribute to the resolution of conflicting cosmological theories.

Most of what we know about the Milky Way and other great galaxies has been learned from starlight. Radio waves now are increasing that knowledge, and still more clues to the origin and structure of the cosmos may be within our reach.

Where We Stand

Clouds of dust and gas hang like veils between much of the universe and our optical and radio telescopes, but cosmic rays dart hither and thither through these veils. The study of cosmic rays made advances in physics possible before great particle accelerators were built on earth; but the immensity and the complexity of electromagnetic processes in space have frustrated efforts to discover where most cosmic rays originate. The study of the intensities of gamma rays which the physicists in the Laboratory for Nuclear Science now plan will be part of efforts

1) to learn more about the clouds of dust and gas, and

2) to determine the sources of cosmic rays.

Gamma rays are like smoke; they may indicate that something has happened. An atom that is hit by a cosmic ray flies apart. The parts include subnuclear particles which, in turn, pop apart – and leave gamma rays. Wherever there are enough wisps of matter and enough cosmic rays, there will be collisions that will produce gamma rays. And these rays are not charged. Hence they are not deflected, as cosmic rays are, by magnetic fields.

We envision the Milky Way now as a great, flat disk of far-flung stuff. Our little solar system is evidently

Prof. Bruno B. Rossi (left) and Herbert S. Bridge, '50, of the M.I.T. Laboratory for Nuclear Science.

The Faraday Cup to be used in the study of the interplanetary plasma will look like this, and be on the surface of a vehicle containing three magnetometers. It is scheduled to be put into orbit by a Thor Delta.

out toward this platter's edge. Consequently, if you could see gamma rays, you should see more of them when you looked toward the center of the galaxy, where there is a greater concentration of stuff, than when you looked up or down or to the right or left. But you might also detect faint beams of gamma rays coming from other dense masses farther away when you looked in the particular directions in which other galaxies have been seen.

A Computing Instrument

To find and, if possible, to measure the intensity of the gamma "smoke" coming from various directions, a gamma ray telescope has been devised. Several such telescopes are being assembled for a variety of tests now, and one of them is scheduled to be sent into space in a suitable satellite.

The M.I.T. gamma ray telescope will be a complex piece of apparatus which requires a great deal of auxiliary equipment. Hence no other experiments will be aboard the satellite that carries this one.

The telescope will be a tubular device consisting of three radiation detectors connected to a computer. At each end of the tube there will be a counting device, and around the whole tube there will be a polystyrene "shield" which also will serve as a counter. The computer will receive signals from all three counters, examine them, and record only the evidence of gamma rays.

When gamma rays strike a scintillation counter at one end of the tube they will be converted into positrons and electrons. These will be detected by a Cherenkov counter at the other end. Cosmic rays will bombard the telescope from all directions, meanwhile, but these will be detected by the shielding, and the computer will be able to subtract their effects from the total. Thus, it will record only the intensity of gamma rays.

For this experiment, of course, the computer must be kept informed regarding the direction in which the telescope is pointed while the gamma rays are being met and measured. It will receive this directional information from a solar sensor and an earth sensor alongside the scintillation counter at one end of the telescope.

To record its findings, a tape recorder will be connected to the computer; and to get the data back to earth, a radio transmitter will be part of the apparatus. A receiver also will be included, so that the computer can be given instructions.

The Orbit

At altitudes which balloons can reach, the gamma ray "smoke" is so dense that it is hard to identify faint differences in its intensity when you look in various directions. And at higher altitudes there is danger of running into a radiation belt, in which the density again would be so great that it would be hard to distinguish the part ascribable to collisions between cosmic rays and bits of matter far off in space. So an effort will be made to put the satellite that carries this gamma ray astronomy experiment into an orbit that will keep it above most of the atmosphere but below a radiation belt most of the time.

Only the part of the satellite that contains the telescope is being built at M.I.T. The whole vehicle will weigh about 80 pounds, and be a rod about seven feet long and a foot in diameter. Part of its exterior will be covered by solar cells to provide electrical power for the apparatus. And a substantial part of the rod will be a solid-fuel rocket.

NASA has provided the funds for both the solar wind and the gamma ray astronomy work at the Institute, and will have charge of the challenging task of hanging the hardware in space properly.

The Faraday Cup for the solar wind study has been designed by Herbert S. Bridge, '50, lecturer in Physics, and Frank Scherb, '53, of the DSR staff, with the help of Ervin F. Lyon, '59, of Lincoln Laboratory and C. Dilworth, a DSR visitor. The gamma ray telescope is being built under the direction of William L. Kraushaar, Associate Professor of Physics, and George W. Clark, '52, Assistant Professor of Physics. All are associated with the cosmic ray group led by Bruno B. Rossi, Professor of Physics.

The Case for Modern Architecture On the Campus

Educational institutions can provide good examples that will heighten appreciation of other fine plans

BY EDWARD D. STONE

ARCHITECTURE is not like millinery: we shouldn't change it just to be fashionable. Yet to me it is encouraging that most of our colleges and universities are changing to beautiful contemporary buildings, in place of the once popular "Collegiate Gothic" or the nondescript structures that we could label "Ugly American."

To use a much-bandied and abused word, the contemporary architect conscientiously tries to produce "functional" buildings. (Whether he succeeds or not is another question.) He tries to plan practically, so that his structures will be suitable to their proposed uses. He does not like to warp his buildings to meet some preconceived design idea.

This point of view is beginning to prevail on campuses in all sections of America, where formerly buildings were often constructed as "monuments" rather than as places where education was to take place, and where the architect was restricted by an accepted design style. Look at the designs for Brandeis University and those for Wayne State University in Detroit, and at the progressive campus done by Frank Lloyd Wright at Florida Southern College. Even campuses that we think of as "traditional" are no longer so. Yale, which has always had a Gothic tradition, now has modern buildings: a fine arts building and an ice-hockey rink. The University of Chicago, for which I am presently doing a continuing-education building, has seen fit to forget its Gothic tradition. The graduate school at Harvard, by Gropius, is a radical departure from that university's colonial traditions. I know of no campus where a rigid style commitment now prevails.

Photo by Reba Wilcoxon

Even Frank Lloyd Wright called Edward D. Stone, '27, "an architect of quality." The Museum of Modern Art in New York, the U.S. Embassy in New Delhi, and the American Pavilion at the Brussels World's Fair are some of the buildings which have made him internationally famous.

He has designed buildings for Stanford University, the University of Arkansas, the University of Chicago, and other schools. His present projects include the National Cultural Center in Washington, D.C., the International Trade Mart in New Orleans, a Tulsa Civic Center, the Huntington Hartford Museum in New York City, and the International College at Beirut.

As my colleague Walter Gropius has pointed out, we don't expect students to go about in period clothes – so why should we build college buildings in pseudo-period design? Like Mr. Gropius, I believe that students reflect their surroundings, and that the appearance and the feeling of one's surroundings make a great deal of difference. If our future architects and future citizens are educated in environments of beauty, perhaps they will go to bat for beauty later in life. (It is no secret that beauty is a scarce commodity in America, one of the few things we can't seem to afford in our land of abundance.)

Architecture, when well done, can create a mood and inspiration. It has done so through the ages. Religious buildings, for example, have inspired religious fervor in their congregations. So it is with a college building: here you can create an atmosphere which is conducive to study and to work, and which produces rapport between teacher and student.

Indeed, the mood may vary with the building. If you are working in a laboratory, you want that laboratory to be like a machine, beautifully equipped and immaculately finished. In a library you want something that gives you a relaxed feeling – an oak-paneled room, carpeting, comfortable chairs, good light, and even an open fireplace.

Even though I am heartily in favor of the encouragement of modern architecture on the American campus, I think that we architects have an obligation to blend the new with the old. This can be done in three principal ways.

First, is the matter of scale. When I say scale – it is an architectural

term—I mean size and proportion. If a campus is made up predominantly of three-story buildings that are, let us say, 100 to 200 feet long, then the new buildings should be relatively the same size.

The second thing to consider is the material that is used, and the color. If a campus was started in a material such as brick or stone, then if possible the same material should be used for the modern buildings. If not the same material, then certainly a harmonizing color can be used.

The third great unifying force is the grouping or arrangement of the buildings. Fortunately, many colleges were started on the quadrangle plan — an ideal grouping for educational buildings. The quadrangle is in effect an outdoor room that unifies a group of buildings, even though they may differ individually in architectural design.

A History of Taste

Of this kind of planning, the best example I know is Harvard. Harvard has adhered to the quadrangle idea; it has used, by and large, the red brick of the original buildings; but it has changed the style as tastes have changed. There are buildings in the Harvard Yard by Richardson in the Romanesque style; there are buildings in the classical revival style by McKim, Mead, and White; there are even Victorian buildings. But because they are placed around quadrangles, towered over by gigantic elms, they are harmonious.

It is highly desirable for a college campus, which is to last hundreds of years, to report the changing tastes of the times. If we look to Oxford and Cambridge, we see a record of this changing history of architecture; yet they are so planned and unified by size, materials, and arrangement that everything ties together. And that's my preference, rather than to saddle the architect and the institution with a preconceived idea of style.

In designing the medical school and hospital at Stanford — which represents my own current tastes and prejudices, if you will — I tried very hard to meet the conditions of blending the new with the old. The site was adjacent to an old quadrangle of low, three-story buildings designed by Shepley, Rutan, and Coolidge, in the tradition of Richardson. I felt that I was working in very distinguished company and that my building should be sympathetic with its predecessors. As a result I made a horizontal hospital—a low three-story building — which is rather unusual for a 400-bed hospital in this day. All the rooms are directly related to landscaped gardens, which in turn are tied in with the beautiful landscaping and fine live oak trees on the 7000-acre campus.

Because of the earthquake problem in that area of California, we thought it desirable to use poured concrete. To make the concrete texture sympathetic with the rough stone of the earlier buildings, and to lend an air of permanence as well, I hit upon the idea of putting within the forms a geometric pattern. This was done by nailing wooden blocks in the forms and then pouring in the concrete, much as you would pour dough into a waffle iron. The result, I believe, is beautiful and exciting — and I hope I have caught the essence of the older buildings, without either copying or ignoring them.

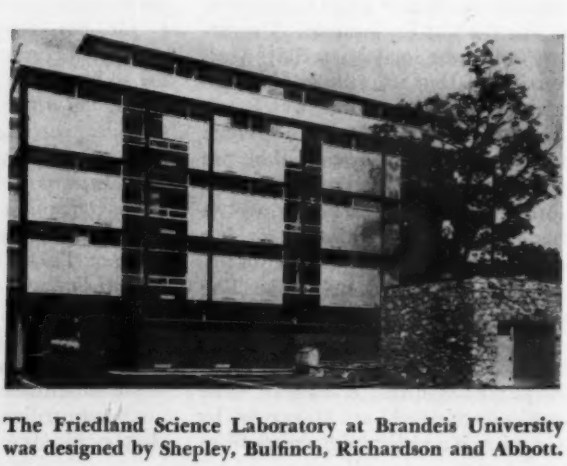
Capturing the Spirit

Using surrounding buildings as a point of departure, I find that I can ask myself: What makes this building unique from all others? If I can find the salient characteristic, I believe there is a much greater chance of doing an original, creative work. In other words, if I am working on a campus that is predominantly red-brick colonial, I try to create something original and contemporary, but which retains some of the qualities that made the colonial structure attractive — capturing the spirit, you might say.

Although my tastes in architectural design have changed since 1950, I have always been happy with the fine arts center at the University of Arkansas. Here is a unique college building, with all the arts — theater, music, painting and sculpture, architecture — under one roof, capturing the spirit of art and serving as an inspiring educational institution.

I have also been concerned with the question of uniqueness of function in designing the center for continuing education at the University of Chicago, to be completed in 1961. Behind it is the theory — and it is a very reassuring one to a man of my age — that one doesn't stop learning. To provide a place where men can return to the campus to live and work in a highly intensive manner for a limited period, I have

The Fine Arts Center at the University of Arkansas still pleases the author although his tastes have changed.



The Friedland Science Laboratory at Brandeis University was designed by Shepley, Bulfinch, Richardson and Abbott.

combined a classroom building, a hotel, and a conference-room building in a simple, unified, rectangular plan.

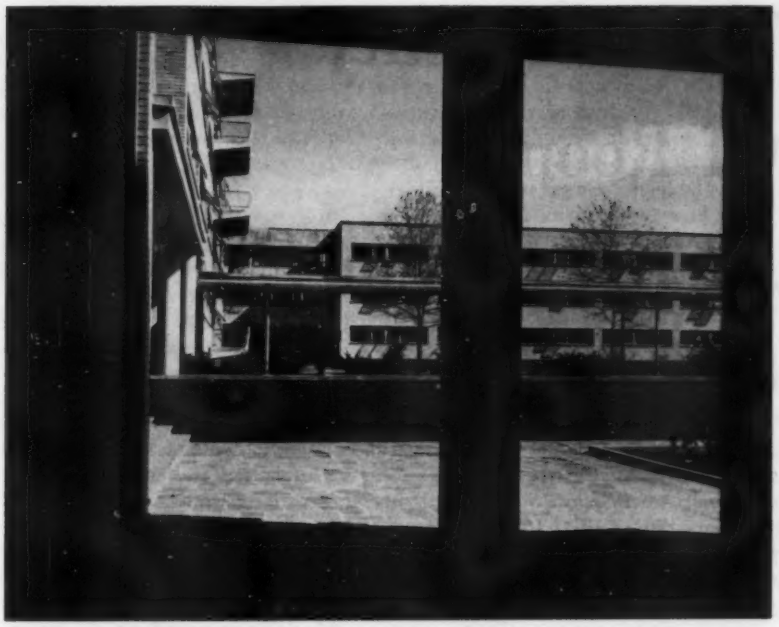
Too often, I am afraid, contemporary architects use the excuse of "functionalism" to indulge their current enthusiams. We are all guilty of enthusiams, of course. To some architects redwood is God's greatest gift to man. To others, plate glass has a place today that Pentelic marble did in the time of the Greeks. Steel in tension holds another architect's world together. I am not given to flexing my structural muscles in public and am content to hobble along on the old post and beam. All of these points of view are healthy, but they should not become standardized and arbitrary — on the college campus or anywhere else.

If members of the boards of college trustees are apprehensive at the mention of using "modern" design at their institutions, it is because they have seen some horrible examples of architecture passing under that label. I am willing to admit that the standards of contemporary architecture in this country are not as high as they might be.

In a country with some 177 million people, there are only about 22,000 architects. Obviously their efforts cannot even approximate the needs for building and rebuilding in the United States. Also, of the approximately $60 billion spent each year on construction, less than one third is for buildings designed by architects. It is a strange paradox that designing and planning are the most important (and the least expensive) part of any project, yet are not considered indispensable.

By and large, universities offering training in architecture fulfill their mission very successfully, arousing enthusiasm and a love of architecture in their students. But since the demand for architects' services is not high, they are beset by the temptation to compromise good design in favor of economic survival. How many college buildings are not what the architect intended but a composite of what boards of trustees, administrators, faculty members, and legislators demanded!

Then, too, the architects themselves are not always capable of good design. They may be too hot in their pursuit of novelty. We unnecessarily complicate our buildings in an effort to do something different, so that the results are too self-conscious, too full of effort to be new and world-shaking. Restraint is important in art as well as in living.



Harvard has adhered to the quadrangle idea, but changed the style as tastes have changed. This is Harvard's new Graduate Center.

What Colleges Can Do

A related fault is the hasty acceptance of the fashionable, so that we have the "glass box" copied everywhere — like a new bonnet the ladies are wearing this season. Obviously the glass building is not suitable to some climates and locations, particularly where there are extreme temperatures. Also, I happen to believe that the glass box fails to fulfill a fundamental need within the heart of man, some inner need for enrichment and embellishment of his surroundings — what I have facetiously called "moxie." I do not mean decoration for its own sake, but the psychological satisfaction that comes, for example, from the pattern of light and shade.

All of these abuses have understandably made some of our colleges leery of embarking upon the "modern" course of campus architecture.

Fortunately, the colleges themselves can help correct these conditions. How? By teaching our cultural heritage, and by themselves serving as examples of what long-range planning can mean in architecture.

One of the functions of education is to teach us the appreciation of and the *uses* of the past. If one knows about the history of architecture, he will also know that modern architecture is adolescent. We have been working on this for only about thirty years. The Greeks produced the Parthenon — which is, after all, a simple building — after 300 years of working with the problem.

With so many rapidly changing conditions of construction — such as air conditioning, new kinds of heating, and the development of the aluminum or glass curtain wall — the architect today has many more chances to go wrong than did the Greek builder. We simply have not yet mastered the fabulous vocabulary with which we have to work. The educated man knows the best of the past, and he knows that he should not be premature in judging the work of the present.

It is part of the obligation of an educational institution to bring to all students this knowledge of the arts and their relationships, no matter what the specialization. When Winston Churchill lectured at M.I.T., he said that he was grati-

(Concluded on page 44)

There's Plenty Of Room At the Bottom

BY RICHARD P. FEYNMAN

This is part of a talk given by Richard P. Feynman, '39, Professor of Physics at the California Institute of Technology, at a recent Caltech meeting of the American Physical Society. Fortune *magazine has hailed Dr. Feynman (who is pictured at the right) as one of our country's most distinguished physicists. The full text of this invitation to enter an exciting new field of study was published in the February, 1960, issue of* Science and Engineering, *the California Institute of Technology's alumni magazine.*

WHAT I want to talk about is the problem of manipulating and controlling things on a small scale.

As soon as I mention this, people tell me about miniaturization, and how far it has progressed today. They tell me about electric motors that are the size of the nail on your finger. And there is a device on the market, they tell me, by which you can write the Lord's Prayer on the head of a pin. But that's nothing; that's the most primitive, halting step in the direction I intend to discuss. It is a staggeringly small world that is below. In the year 2000, when they look back at this age, they will wonder why it was not until the year 1960 that anybody began seriously to move in this direction.

Why cannot we write the entire 24 volumes of the Encyclopaedia Brittanica *on the head of a pin?*

Let's see what would be involved. The head of a pin is a sixteenth of an inch across. If you magnify it by 25,000 diameters, the area of the head of the pin is then equal to the area of all the pages of the *Encyclopaedia Brittanica*. Therefore, all it is necessary to do is to reduce in size all the writing in the encyclopaedia by 25,000 times. Is that possible? The resolving power of the eye is about 1/120th of an inch — that is roughly the diameter of one of the little dots on the fine halftone reproductions in the encyclopaedia. This, when you demagnify it by 25,000 times, is still 80 angstroms in diameter — 32 atoms across, in an ordinary metal. In other words, one of those dots still would contain in its area 1,000 atoms. So, each dot can easily be adjusted in size as required by the photoengraving. and there is no question that there is enough room on the head of a pin to put all of the *Encyclopaedia Brittanica*.

Furthermore, it can be read if it is so written. Let's imagine that it is written in raised letters of metal; that is, where the black is in the encyclopaedia, we have raised letters of metal that are actually 1/25,000 of their ordinary size. How would we read it?

We Can Read Small

If we had something written in such a way, we could read it using techniques in common use today. (They will undoubtedly find a better way when we do actually have it written, but to make my point conservatively I shall just take techniques we know today.) We would press the metal into a plastic material and make a mold of it, then peel the plastic off very carefully, evaporate silica into the plastic to get a very thin film, then shadow it by evaporating gold at an angle against the silica so that all the little letters would appear clearly, dissolve the plastic away from the silica film, and then look through it with an electron microscope!

The next question is: How do we *write* it? We have no standard technique to do this now. But let me argue that it is not as difficult as it first appears to be. We can reverse the lenses of the electron microscope in order to demagnify as well as magnify. A source of ions, sent through the microscope lenses in reverse, could be focused to a very small spot. We could write with that spot like we write in a TV cathode-ray oscilloscope, by going across in lines, and having an adjustment which determines the amount of material which is going to be deposited as we scan in lines.

This method might be very slow because of space charge limitations. There will be more rapid methods. We could first make, perhaps by some photo process, a screen which has holes in it in the form of the letters. Then we would strike an arc behind the holes and draw metallic ions through the holes; then we could again use our system of lenses and make a small image in the form of ions, which would deposit the metal on the pin.

A simpler way might be this (though I am not sure it would work): We take light and, through an optical microscope running backwards, we focus it onto a very small photoelectric screen. Then electrons come away from the

screen where the light is shining. These electrons are focused down in size by the electron microscope lenses to impinge directly upon the surface of the metal. Will such a beam etch away the metal if it is run long enough? I don't know. If it doesn't work for a metal surface, it must be possible to find some surface with which to coat the original pin so that, where the electrons bombard, a change is made which we could recognize later.

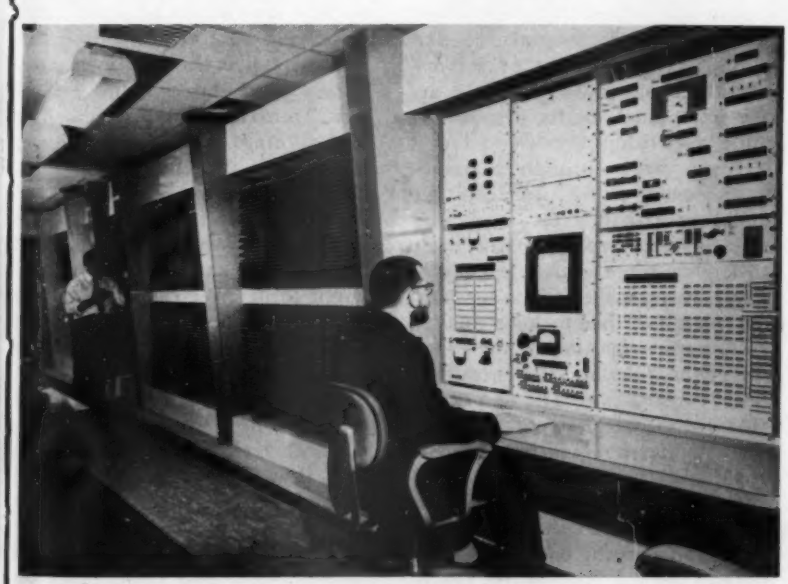
There is no intensity problem in these devices — not what you are used to in magnification, where you have to take a few electrons and spread them over a bigger and bigger screen; it is just the opposite. The light which we get from a page is concentrated onto a very small area so it is very intense. The few electrons which come from the photoelectric screen are demagnified down to a very tiny area so that, again, they are very intense. I don't know why this hasn't been done yet!

24,000,000 Books

That's the *Encyclopaedia Brittanica* on the head of a pin, but let's consider all the books in the world. The Library of Congress has approximately nine million volumes; the British Museum Library has five million volumes; there are also five million volumes in the National Library in France. Undoubtedly there are duplications, so let us say that there are some 24 million volumes of interest in the world.

What would happen if I were to print all this down at the scale we have been discussing? How much space would it take? It would take, of course, the area of about a million pinheads because, instead of there being just the 24 volumes of the *Encyclopaedia*, there are 24 million volumes. The million pinheads can be put in a square of a thousand pins on a side, or an area of about three square yards. That is to say, the silica replica with the paper-thin backing of plastic, with which we have made the copies, with all this information, is on an area of approximately the size of 35 pages of the *Encyclopaedia*. All of the information which all of mankind has ever recorded in books can be carried around in a pamphlet in your hand — and not written in code, but as a simple reproduction of the original pictures, engravings, and everything else.

Now, the name of this talk is "There Is Plenty of Room at the Bottom" — not just "There Is Room at the Bottom." What I have demonstrated is that there *is* room — that you can decrease the size of things in a practical way. I now want to show that there is *plenty* of room. I will not now discuss how we are going to do it, but only what is possible in principle — in other words, what is possible according to the laws of physics. I am not inventing antigravity, which is possible someday only if the laws are not what we think. I am telling you what could be done if the laws *are* what we think; we are not doing it simply because we haven't yet gotten around to it.



The central computer unit of Whirlwind I occupied 225 lineal feet of racks 10 feet high. The central unit of Lincoln Laboratory's TX-2, shown here, occupies only 48 lineal feet of racks 6 feet high. In this seven times smaller size, TX-2 packs 8 times the computing rate and 25 times the high-speed memory capacity.

Codes in Cubes

Suppose that, instead of trying to reproduce the pictures and all the information directly in its present form, we write only the information content in a code of dots and dashes, or something like that, to represent the various letters. Each letter represents six or seven "bits" of information; that is, you need only about six or seven dots or dashes for each letter. Now, instead of writing everything, as I did before, on the *surface* of the head of a pin, I am going to use the interior of the material as well.

Let us represent a dot by a small spot of one metal, the next dash by an adjacent spot of another metal, and so on. Suppose, to be conservative, that a bit of information is going to require a little cube of atoms 5 x 5 x 5 — that is 125 atoms. Perhaps we need a hundred and some odd atoms to make sure that the information is not lost through diffusion or some other process.

I have estimated how many letters there are in the *Encyclopaedia*, and I have assumed that each of my 24 million books is as big as an *Encyclopaedia* volume, and have calculated, then, how many bits of information there are (10^{15}). For each bit I allow 100 atoms. And it turns out that all of the information that man has carefully accumulated in all the books in the world can be written in this form in a cube of material one two-hundredth of an inch wide — which is the barest piece of dust that can be made out by the human eye. So there is *plenty* of room at the bottom! Don't tell me about microfilm! . . .

A friend of mine (Albert R. Hibbs) suggests a very interesting

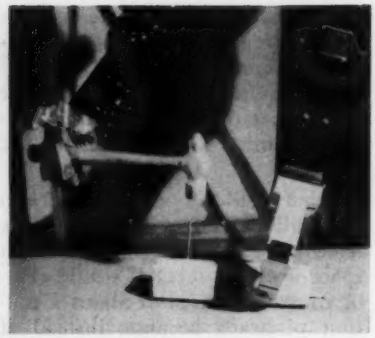
possibility for relatively small machines. He says that, although it is a very wild idea, it would be interesting in surgery if you could swallow the surgeon. You put the mechanical surgeon inside the blood vessel and it goes into the heart and "looks" around. (Of course the information has to be fed out.) It finds out which valve is the faulty one and takes a little knife and slices it out. Other small machines might be permanently incorporated in the body to assist some inadequately functioning organ.

Now comes the interesting question: How do we make such a tiny mechanism? I leave that to you. However, let me suggest one weird possibility. You know, in the atomic energy plants they have materials and machines that they can't handle directly because they have become radioactive. To unscrew nuts and put on bolts and so on, they have a set of master and slave hands, so that by operating a set of levers here, you control the "hands" there, and can turn them this way and that so you can handle things quite nicely.

Most of these devices are actually made rather simply, in that there is a particular cable, like a marionette string, that goes directly from the controls to the "hands." But, of course, things also have been made using servo motors, so that the connection between the one thing and the other is electrical rather than mechanical. When you turn the levers, they turn a servo motor, and it changes the electrical currents in the wires, which repositions a motor at the other end.

Smaller and Smaller Hands

Now, I want to build much the same device — a master-slave system which operates electrically. But I want the slaves to be made especially carefully by modern large-scale machinists so that they are one-fourth the scale of the "hands" that you ordinarily maneuver. So you have a scheme by which you can do things at one-quarter scale anyway — the little servo motors with little hands play with little nuts and bolts; they drill little holes; they are four times smaller. Aha! So I manufacture a quarter-size lathe; I manufacture



This hydromechanical pair of slave hands can perform a wide variety of mechanical tasks precisely.

quarter-size tools; and I make, at the one-quarter scale, still another set of hands again relatively one-quarter size! This is one-sixteenth size, from my point of view. And after I finish doing this I wire directly from my large-scale system, through transformers perhaps, to the one-sixteenth-size servo motors. Thus I can now manipulate the one-sixteenth size hands.

The Precision Problem

Well, you get the principle from there on. It is rather a difficult program, but it is a possibility. You might say that one can go much farther in one step than from one to four. Of course, this has all to be designed very carefully and it is not necessary simply to make it like hands. If you thought of it very carefully, you could probably arrive at a much better system for doing such things.

If you work through a pantograph, even today, you can get much more than a factor of four in even one step. But you can't work directly through a pantograph which makes a smaller pantograph which then makes a smaller pantograph — because of the looseness of the holes and the irregularities of construction. The end of the pantograph wiggles with a relatively greater irregularity than the irregularity with which you move your hands. In going down this scale, I would find the end of the pantograph on the end of the pantograph on the end of the pantograph shaking so badly that it wasn't doing anything sensible at all.

At each stage, it is necessary to improve the precision of the apparatus. If, for instance, having made a small lathe with a pantograph, we find its lead screw irregular — more irregular than the large-scale one — we could lap the lead screw against breakable nuts that you can reverse in the usual way back and forth until this lead screw is, at its scale, as accurate as our original lead screws, at our scale.

We can make flats by rubbing unflat surfaces in triplicates together — in three pairs — and the flats then become flatter than the thing you started with. Thus, it is not impossible to improve precision on a small scale by the correct operations. So, when we build this stuff, it is necessary at each step to improve the accuracy of the equipment by working for awhile down there, making accurate lead screws, Johansen blocks, and all the other materials which we use in accurate machine work at the higher level. We have to stop at each level and manufacture all the stuff to go to the next level — a very long and very difficult program. Perhaps you can figure a better way than that to get down to small scale more rapidly. . . .

Atoms in a Small World

When we get to the very, very small world — say circuits of seven atoms — we have a lot of new things that would happen that represent completely new opportunities for design. Atoms on a small scale behave like *nothing* on a large scale, for they satisfy the laws of quantum mechanics. So, as we go down and fiddle around with the atoms down there, we are working with different laws, and we can expect to do different things. We can manufacture in different ways. We can use, not just circuits, but some system involving the quantized energy levels, or the interactions of quantized spins, etc.

Another thing we will notice is that, if we go down far enough, all of our devices can be mass produced so that they are absolutely perfect copies of one another. We cannot build two large machines so that the dimensions are exactly the same. But if your machine is only 100 atoms high, you only have

(Concluded on page 46)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

The rapid development of the modern submersible water pump has resulted in the development of new applications for old metals.

Recently one of Revere's Technical Advisors was called in by a prominent manufacturer of this type pump for consultation regarding the diffuser casing which is a working part located in the interior of their pump used in deep and shallow wells. It was made of a ferrous metal and, while it functioned satisfactorily as a part, it proved difficult to fabricate. In addition, tool life was alarmingly short. After studying the problem in cooperation with the manufacturer's engineers, and consulting with the Revere Mills, Revere cartridge brass strip of a certain temper was recommended.

Samples were submitted, and after extensive tests approved for the part. The customer has found that not only does the diffuser casing, made of Revere Brass, perform well in the pump, but it also has superior drawing properties, is more easily worked, and tool life has been substantially increased.

This meticulous attention to "fitting the metal to the job" also resulted in this manufacturer's specifying Revere seamless leaded brass tubing for the upper body shell of its submersible pumps. Here the application called for extremely close straightness and roundness control which meant special attention to detail on the part of the Revere Mills.

You have just read of two more examples of the vital importance of selecting the metal that is not only satisfactory from a functional standpoint but one that is equally satisfactory from a production standpoint. For, what may be saved on one hand can very well be lost on the other, if the metal is not properly balanced to fit the conditions met, both in use and in fabrication.

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Winter Sports Review Shows Many Victories

IN M.I.T.'s varied winter sports campaign this year, the swimmers, wrestlers, and skiers stood out.

In swimming, Coach Charles Batterman's team posted a 7-3 slate for the second consecutive year, broke 13 M.I.T. records, and finished fourth in the New England championships with two individual titles.

Burnell West, '60, won the New England breast stroke championship and during the season equaled the New England record of 2:29.1. He also swam on the greatest medley relay in Tech history, with Thomas Ising, '61, Antonio Silvestri, '61, and John Windle, '60, which won the New England medley crown in 4:04.6. Ising was defeated only once in 20 events during the season, and West only twice. In diving, William Bails, '62, took third in the New Englands.

Freshman swimmers broke seven records as they splashed their way to an 8-2 slate this season.

In wrestling, Coach Alex Sotir's varsity compiled a 5-3 and two-ties record. John Sullivan, '61, was undefeated in his first seven matches in the 147-pound division and Andrew Bulfer, '61, had a 6-2 record with the 137-pounders. The squad ran up more points (149) than the total for the three previous seasons.

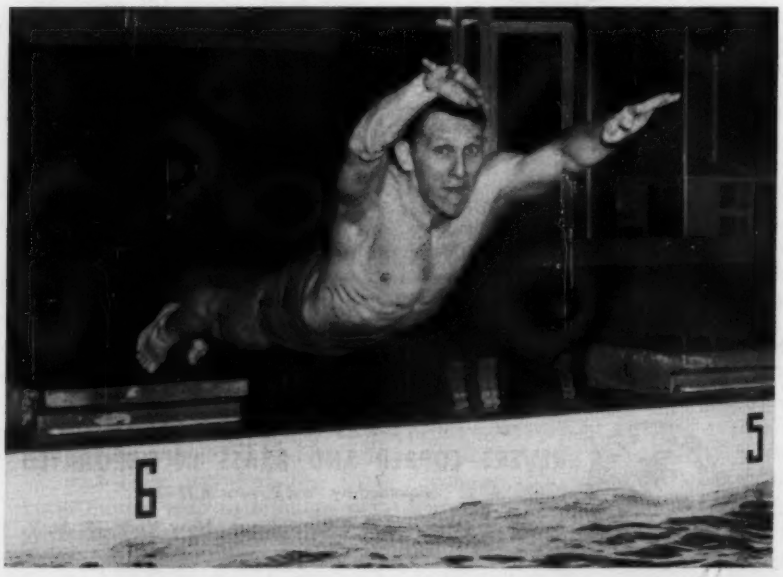
The freshmen finished third in the New Englands, with a 5-2 record, and were considered the most promising squad in many years. James Evans, '63, was undefeated at the 130-pound weight.

Skiers (from left to right) are Dirk Berghager, '62, Peter P. Goldstern, '62, Theodore H. Ansbacher, '60, Ulf B. Heide, '60, Roberto Peccei, '62, Giorgio Emo, '62, and Coach Robert Shoemaker in the Du Pont Athletic Center.

In skiing, Coach Bob Shoemaker's men won another New England championship. They won six meets.

Peter Goldstern, '62 was fourth in New England standing, followed by Roberto Peccei, '62.

A highlight of their campaign was the rallying victory at Killington Basin, Vt., when Goldstern and Peccei finished one-two in a downhill race that hit 55-m.p.h. speeds.



John Windle, '60, was captain of the stellar 1959-1960 Swimming Team.

Donald Weaver, '60, headed wrestlers.

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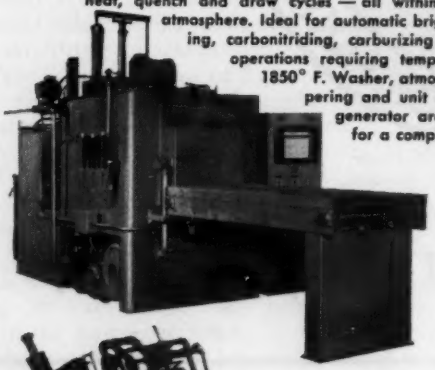

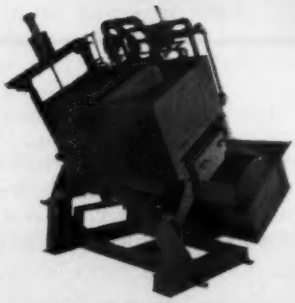

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Books

VIRUS HUNTERS, by Greer Williams; Alfred A. Knopf, Inc. ($5.95). *Reviewed by Alexander Rich, Associate Professor of Biophysics, M.I.T.*

VIRUS HUNTERS is Mr. Williams' name for the group of scientists who have carved out our understanding of the structure and behavior of the smallest organisms which exist in biological systems. His book is a highly entertaining and provocative account of the young science of virology. It obviously is patterned after Paul de Kruif's *Microbe Hunters* (first published in 1926) which told in very entertaining fashion the story of man's conquest of the bacterial cell and, by telling the story in terms of the lives of the scientists, became a best seller for over two decades.

Mr. de Kruif's book was written largely about men who were no longer alive and, accordingly, he had a great deal of journalistic latitude in describing the aspirations, frustrations, and idiosyncrasies of the scientists who studied bacteria. Virology, however, is a young science and most of the men who appear in Williams' *Virus Hunters* are alive and still actively pursuing their science. This has an advantage, in that it enabled Williams to speak with men such as Wendell Stanley, John Enders, Jonas Salk, and other contemporary leaders of virology, but also constrained him somewhat in that his description of these contemporary scientists had to cleave close to the facts.

The book is written in a racy, journalistic style which keeps the interest of the reader. Williams tells an essentially chronological story, starting with Jenner and the beginnings of vaccination, and continuing through Pasteur into the modern era. The book has a rather heavy bias in the direction of medical virology and, accordingly, treats in great detail diseases such as influenza, virus hepatitis, measles, and polio. Indeed, a whole section of the book is devoted to the polio story, which is told with considerable clarity. An account of John Enders' substantial contributions to the development of tissue-culture methods for producing polio virus gives proper scientific perspective to the polio vaccine. In glowing detail, Williams paints the development of the Salk vaccine together with its problems and frustrations. The author builds up a great deal of suspense in the reader over the cause for the initial failures and tragedies which were attendant to the use of the Salk vaccine. On the whole, Williams' account is very lively and readable.

In a concluding section on cancer, genes, and "the Heart of the Virus Matter," Williams sketchily outlines a good deal of what today is broadly known as molecular biology. He points out the various theories which scientists have regarding the role of viruses in the origin of cancer. This is at present a very active field of research. In addition, some reference is made to the importance of the nucleic acids in reaching a

(Continued on page 38)

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Books

(Continued from page 36)

molecular understanding of the functioning of biological systems. A few technical errors appear in the manuscript, such as referring to nucleotide linkages as peptide bonds, but this does not mar the narrative.

Virus Hunters can be recommended as an entertaining introduction to an active area of science.

CRYSTALS AND CRYSTAL GROWING, by Alan Holden and Phylis Singer; Doubleday & Co. ($1.45). *Reviewed by Martin Mann, '41, Senior Editor of Popular Science Monthly.*

THE simple-minded questions are the toughest. That this fascinating book answers so many, simply and directly, is only one of its several distinctions.

Possibly you already know that hard and rigid glass is not really solid. (Its atoms are not filed in orderly crystals, and only crystals are true solids.) And you may also know one clue to glass's amorphous nature. (It lacks a sharp melting point, gradually softening when heated.) But did you know why crystals change suddenly from solid to liquid, while glass does not? A crystal is uniform; when increasing temperature adds enough energy to shake its tiny units out of position, all the units fall free and flow as a liquid. Glass, on the other hand, is a disordered conglomeration, so rising temperature permits one molecule after another to slide around its neighbors.

And did you know what makes solids dissolve in liquids? The solvent either weakens the forces that lock the solid molecules together or else pulls on the molecules harder than these attractive forces (or sometimes does both). Or why water is a superlative solvent? It possesses an exceptional ability to reduce electric forces of attraction between molecules.

Such intriguing tidbits are an integral part of the fundamental understanding of nature that Alan Holden and Phylis Singer provide as they explain crystals. They start at the beginning (the differences distinguishing solids, liquids, and gases) and carry the reader on to what seems to me a fairly sophisticated discussion of the structure and habits of solid matter.

Roughly one-third of their book is devoted to this kind of exposition. The middle third is straight how-to-do-it: methods and recipes for growing and experimenting on a variety of beautiful crystals. The remainder explains how scientists study, manipulate, and classify crystals – this section, I suspect, will separate the *aficionados* from the casually curious. Four pages in the appendix merit special note: They outline 10 research problems that are much more than routine projects for science fairs.

The writing is clear, straightforward, and occasionally graceful. There are many explanatory drawings – and a good selection of photographs. The authors hew to the party line of their sponsors, the Physical Science Study Committee; they describe crystallography as a pure science, worth studying for its own sake. Nowhere will you find a hint of the exciting technology (transistors, magnets, superstrong metals) that is evolving from our new understanding of crystals.

(Concluded on page 40)

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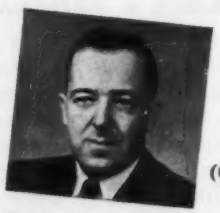

JACK M. WILLIAMS
New York Life representative at the Cimarron (Oklahoma City) Okla. General Office

Education: Rutgers Univ., B.S., '48

Military: U.S. Navy '42–47; Lieut., USNR

Employment Record: Joined Nylic Oct. '52; Member six years, Star Club (organization of company's leading agents)

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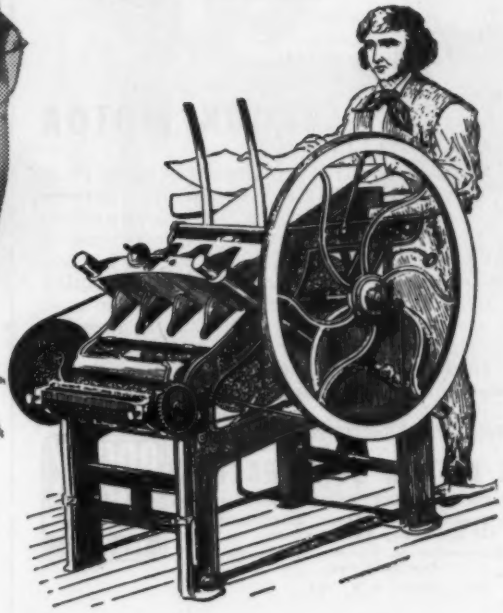

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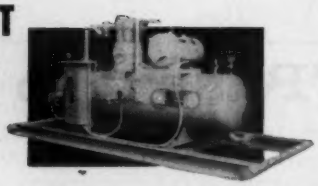

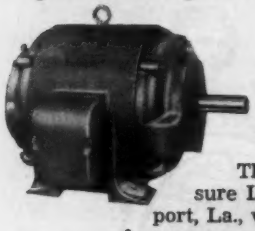

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Books

(Concluded from page 38)

A Variety of Topics

RECENT BOOKS by Alumni and the M.I.T. Faculty's members include:

Circuit Theory of Linear Noisy Networks, by Hermann A. Haus, '54, and Richard B. Adler, '43, of the M.I.T. Department of Electrical Engineering (John Wiley & Sons, Inc., $4.50).

Fire Control Principles, by Walter Wrigley, '34, and John Hovorka of the M.I.T. Instrumentation Laboratory (McGraw-Hill Book Co., $10).

Fluid Power Control, edited by John F. Blackburn, Gerhard Reethof, '47, and J. Lowen Shearer, '50, of the M.I.T. Dynamic Analysis and Control Laboratory (Technology Press, $17.50). The contributors include Richard H. Frazier, '23, John A. Hrones, '34, Shih-ying Lee, '43, Henry M. Paynter, '44, James L. Coakley, '51, Frederick D. Ezekiel, '51, Thomas E. Hoffman, '51, and Alan H. Stenning, '51.

Introduction to Geophysical Prospecting, by Milton B. Dobrin, '36 (McGraw-Hill Book Co., $9.50). This is a second edition covering technical advances since 1950.

Primer of Lamps and Lighting, by Willard J. Allphin, '25, (Chilton Co., $10).

The United States in the World Arena, by Walt W. Rostow, Professor of Economic History at M.I.T. (Harper & Brothers, $8.75).

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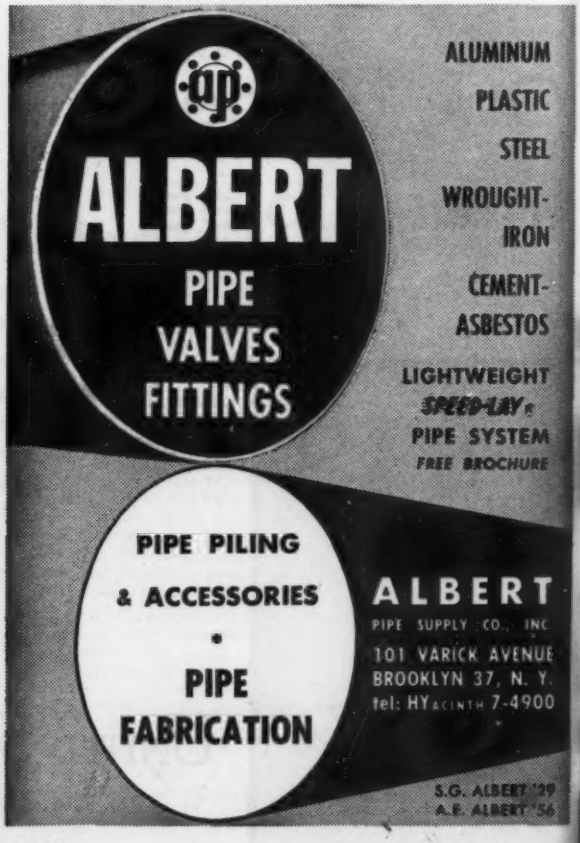
Trend of Affairs
(Concluded from page 20)

Learning From Tape

TAPE RECORDINGS of law cases are being produced by Stanley M. Jacks of the M.I.T. School of Industrial Management to make labor-management problems more stimulating and understandable.

The first two-hour tape of a series that he plans is a recording of the proceedings and the comments of participants in a case involving the Mount Hope Finishing Company of North Dighton, Mass., and the Textile Workers Union. The Union took this case to the National Labor Relations Board, but its decision was reversed later by the U.S. Court of Appeals. Locating the principals, obtaining permission, recording their remarks, and editing the voluminous record took a year and a half.

"Although I recognize that audio-visual methods are used in teaching law as well as other subjects," says its producer, "I feel that this is the first example of comprehensive tape recording in which the voices of actual participants are used. As a result, the tape has been borrowed for use in classes at a number of colleges. Students gain an understanding of the complexities of legal proceedings, and in being confronted by real people involved in a real controversy, find it extremely difficult to maintain any pre-listening prejudices as to which side is right. A new image of the problems posed by the case is produced through listening."



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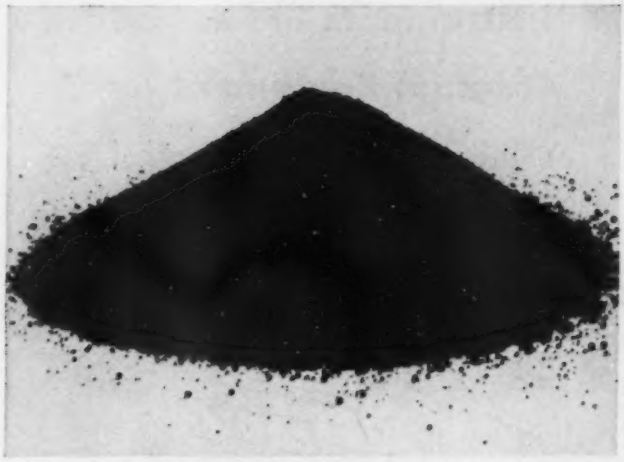

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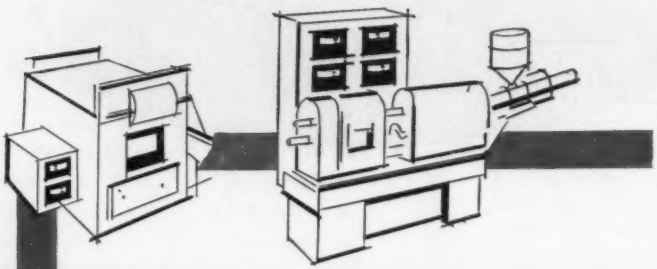

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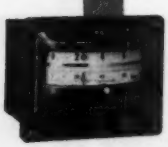

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the trend is to WEST

Modern Campus Architecture

(Concluded from page 29)

fied that such a great scientific and engineering institution found a place for the humanities, giving scientists a background in other things of the spirit which are challenging to every man.

When colleges and universities raise the general level of appreciation of architecture, the results will eventually be seen everywhere. Students become the community leaders who serve on school boards and decide about new buildings; who have ideas for civic improvements in the business districts, in the parks, on the highways. Through general education our people should be taught the importance of beautiful surroundings — which are, after all, a national asset.

In addition, the campuses themselves can serve as good examples of what architectural planning should be. Probably the thing that has caused the most difficulty in the campus of today is that no long-range provisions were made for the campus's development. Because many founders and leaders did not foresee the rapid growth of education, cities have grown up around many institutions and they no longer have elbow room. A crowded, hemmed-in campus is hard-put to be a thing of beauty, even with the best of buildings.

Every educational institution should have a master plan — one that, insofar as it can be, is the vision of able professionals for a future of fifty to one hundred years. Naturally, such a plan will undergo modification as time passes, but at least you are building with some conscientiousness and a final conception in mind. Too many college buildings have been arbitrarily put in the wrong places at the whim of a president or trustee; too many designs and materials have been selected without regard to the appearance of the whole.

Given a plan for the future, every university and college can make a place for the new architecture which will evolve without being prey to every passing fashion. It is never too late to start.

(Copyright, 1960, by Editorial Projects for Education. The Technology Review received this article from this new organization, created to serve alumni publications, and the article also is being published in the magazines of many other schools.)

NEW HORIZONS IN . . .

High Voltage — Corona Resistant — Flexible — Small Diameter Cables

BIW has broken the corona barrier in high voltage wire. A patented process of laminating Teflon tape with a high dielectric oil reduces the incidence of corona by excluding air from the dielectric and protects the Teflon from damaging effects should corona occur. The graph at the right illustrates the long life of Teflon film in oil vs. that in air.

Corona is the result of a void between the conductor and the insulating material or within the insulation. Extruded Teflon is susceptible to separation from the conductor when flexed because of its rigidity and solid mass. Solid Teflon by its very nature contains minute voids within its cross-section. These voids and separations are corona forming points, and without protection the Teflon is subject to deterioration, which degrades the cable.

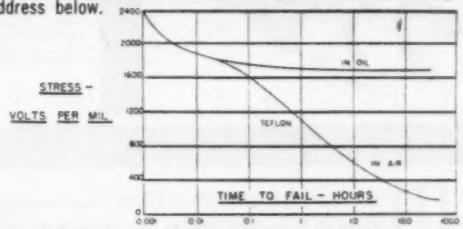
BIW uses thin Teflon tapes, so that any void within the tape is extremely small. In addition, the tape is surrounded with a viscous high temperature — high dielectric oil. Through these techniques, BIW offers a flexible cable with the highest corona threshold in the smallest size.

Braided or extruded jackets are available. FEP extruded Teflon jackets are resistant to acids, alkalies, solvents, abrasion, ozone, ultra-violet, water absorption, oils, fluids, temperatures to 200° C and will not flow at temperatures up to 250° C. With this type jacket, the cable strips easily, has no braids to leak at high voltage or fray when cut and prevents unravelling of taped dielectric.

BIW laminated Teflon tape and oil constructions demonstrate great reliability over a wide temperature range, are light in weight, and are available in a variety of colors.

Typical uses of these cables are on power plant ignition, high temperature transformers, ignition for continuously operating internal combustion motors, chemical processing apparatus, tube cap leads — high voltage, high temperature generator leads — and on a variety of electronic equipment.

Write for more information on: BIW Type PFTX, PFGV, PFDL. Your BIW representative will be happy to discuss this and any other wire and cable constructions with you. Contact us today at the address below.



THIS GRAPH shows voltage-life tests of Teflon film 0.005" in thickness. Note the comparative long life of Teflon protected with oil. BIW process for manufacturing Teflon insulated cables protects with dielectric oil.

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Room at the Bottom

(Concluded from page 32)

to get it correct to one-half of one per cent to make sure the other machine is exactly the same size—namely, 100 atoms high!

At the atomic level, we have new kinds of forces and new kinds of possibilities, new kinds of effects. The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom. It is not an attempt to violate any laws; it is something, in principle, that can be done; but, in practice, it has not been done because we are too big. . . .

But it is interesting that it would be, in principle, possible (I think) for a physicist to synthesize any chemical substance that the chemist writes down. Give the orders and the physicist synthesizes it. . . .

High School Fun

Just for the fun of it, and in order to get kids interested in this field, I would propose that someone who has some contact with the high schools think of making some kind of high school competition. After all, we haven't even started in this field, and even the kids can write smaller than has ever been written before. They could have competition in high schools. Los Angeles high school could send a pin to the Venice high school on which it says, "How's this?" They get the pin back, and in the dot of the *i* it says, "Not so hot."

Perhaps this doesn't excite you to do it, and only economics will do so. Then I want to do something; but I can't do it at the present moment, because I haven't prepared the ground. It is my intention to offer a prize of $1,000 to the first guy who can take the information on the page of a book and put it on an area 1/25,000 smaller in linear scale in such manner that it can be read by an electron microscope.

And I want to offer another prize—if I can figure out how to phrase it so that I don't get into a mess of arguments about definitions—of another $1,000 to the first guy who makes an operating electric motor—a rotating electric motor which can be controlled from the outside and, not counting lead-in wires, is only a 1/64-inch cube.

What are your chances of earning $30,530 a year?

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D-C AMPLIFIER EVALUATION *number 1 in a series*

AMPLIFIER NOISE

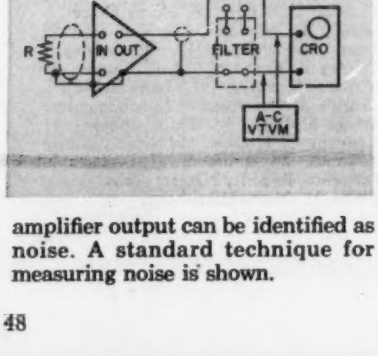
Accuracy is the basic objective in amplifier selection. When evaluating amplifiers for specific applications all errors must be considered. One such error, the noise level, determines the ultimate accuracy of the amplifier since the smallest observable signal cannot be less than the noise level. However, noise outside the frequency response range of the amplifier load can be filtered out or ignored with such read-out devices as galvanometer oscillographs.

Noise in an amplifier is any voltage component appearing at the output that has no counterpart in the input signal. Usually only the a-c component of the output is termed noise. The d-c component is called zero drift and its evaluation will be covered in another of this series.

Internally generated a-c components must be evaluated as to amplitude and frequency range. Noise may be divided into two general classes and measured as described below. (a) *Random voltages* of a broad band nature arising from thermal agitation in resistors and random tube or transistor noise . . . measurements on a peak-to-peak basis are often 10 times or more larger than the measured rms value over the same frequency band. (b) *Narrow band voltages* induced within the amplifier by line voltage or chopper excitation . . . these voltages are generally sinusoidal so that peak-to-peak values are only about 2.8 times larger than the measured rms values.

Testing amplifiers for noise

If the input signal is zero, any voltage components detected at the amplifier output can be identified as noise. A standard technique for measuring noise is shown.



The oscilloscope measures the peak-to-peak values, the VTVM in rms values. Equivalent input noise (eq. in) is the measured noise divided by the amplifier gain. For details write for Bulletin BE AN121.

Noise less than 0.03%

With a full scale input range of 30 mv, Honeywell's AccuData II Amplifier has a wide band (0-100 KC) noise specification of 8 μv (eq. in) and a peak-to-peak noise over a 0-10 cps band of 8 μv (eq. in) . . . less than 0.03% of full scale!

The AccuData II, a wide band differential input d-c amplifier with all transistor design, is especially useful for driving analog-to-digital converters, f-m magnetic tape systems and high speed oscillographs where low level signals such as thermocouple, strain gage and similar transducer outputs are to be accurately measured. Write for Bulletin BS DISA-1000 to Minneapolis-Honeywell, Boston Division, Dept. 1, 40 Life Street, Boston 35, Mass.

Honeywell
First in Control
SINCE 1885

Feedback

(Continued from page 3)

the classical notation, but rather, in the primary grades especially, it provides a transitory language to a deeper and more penetrating vocabulary.

Thus, I cannot agree with your implication, if this is what it is, that the use of the "new" notation is lightly thrusting aside the efforts of centuries. Properly used, it can provide the fundamental understanding that algebra is a language, as well as a means of solving problems, and, as in all languages, different arrangements of letters and symbols may have the same meaning.

230 Washington Street,
Mount Vernon, N.Y.

The Relevant Facts Lead To "The Larger Learning"

FROM W. E. HOWLAND, '22:

In the article entitled "The Larger Learning" in the Technology Review of March, 1960, Professor Huston Smith rightly pleads for an education that will "promulgate," not only "intellectual honesty," "scope of knowledge," "dialectical agility" and "aesthetic sensitivity" as he says most institutions of higher learning strive to do, but, in addition, "diligence," "moral honesty" and "academic freedom." The former so-called "academic virtues" entail the latter as supports. . . .

In recognizing a distinction between the intellectual and the human or less-intellectual virtues he seems to imply that there is a corresponding difference in methods needed for "promulgating" them — that the intellectual processes, especially reasoning, are appropriate for inculcating the intellectual virtues but that different "guides" or different methods are required for the others. He mentions "example" and "habituation" to a "style of life." Yet surely these means apply with equal force to the cultivation of the more strictly intellectual virtues as well, and are actually employed at our universities and colleges for this high purpose. Likewise, logic applied to the facts of life supports the value of love. He has, I suspect, some other specialized methods in mind for promoting the so-called human virtues, or to use his phrase, developing "spiritual growth."

But why the difference? Is not moral honesty compounded of the same ingredients as intellectual honesty and is not the same also true of diligence, academic and otherwise? And of freedom also? Academic freedom started to become a reality when courageous intellectuals like Galileo and Servetus challenged the power of those ecclesiastics who so zealously guarded the value of authority both of Aristotle and of the church. Freedom in general owes little to the "Larger Learning" of the Middle Ages, but much to the efforts of Renaissance intellectuals.

Love for one's fellow man is, I agree, more than an intellectual virtue since it stems from the very depths of our biological nature — from the herd-instinct, so-called. Proper instruction would point this out as it underscores the importance

of love in life. The intellect has always been required to examine the meaning of this most Christian virtue for Christians have burned and slaughtered Christians—heretics, of course—out of love for their souls and for the greater glory of God. The recognition of the fact—the scientific fact—of the supreme value of love to the individual who loves, and to his family and to society in general, is an intellectual task of great difficulty in the confusion of propaganda that still abounds on behalf of competing and partial values and loyalties for gods, for countries and for Yales—of rival cults, corporations, and country clubs. Organizational salesmanship, an art already highly developed in the Dark Ages, is all-pervasive; concern for people—like music on the radio—is often out-decibelled by the blare of proselyting preachments as well as by the beat of the conscienceless drummers. Perhaps we need the good judgment to turn off the noisy radio still more than we need additional programs, even on behalf of values, to give us time to think about them.

In the main, I accept Professor Smith's judgments on values as he expresses them in this excellent article: what they are and their relative importance. And if he is mistaken the only means of finding his errors and of proving him wrong is intelligent thought.

My views, I admit, belong to the Eighteenth Century, still called the "Enlightenment" by scholars like Professor Smith. Man is basically and predominantly good!

It "lies within" his nature to love the other members of the human species. He does not need to have this virtue instilled into him by the magical arts as by invocation and incantation (pictured between the paragraphs of Professor Smith's article) so much as to be taught the relevant facts via the arts and social sciences and to be helped and encouraged by his teachers to think clearly about all these matters—as he is about atoms and neutrons—so as to be able to expose the false claims and to validate the sound ones of prevailing philosophies. This kind of education will, I feel sure, give his deep-seated humanitarian drives the license they need to express themselves in his life and work, perhaps as an engineer.

So, in my view, the "learning" that he requires even in the "larger" areas of his life turns out to be largely intellectual after all.

Purdue University
Lafayette, Ind.

Another Vote for Boldface

FROM RAYMOND A. SNOW, '21:

I am interested in the comment of Richard W. Willard, '51, in the "Feedback" column of the December issue, relating to the use of boldface type.

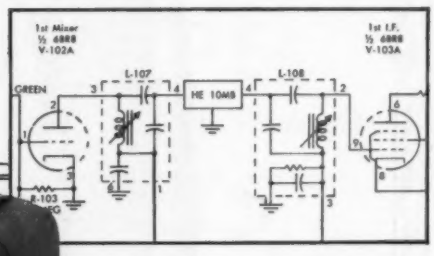
I strongly concur in his suggestion. Very few Alumni have any interest in news about classmates who were not well known to them in their undergraduate days. As the notes are now published it is tiresome to read through lines and lines of notes looking for a familiar name.

I like the new format of The Review.

Raleigh, N.C.

FIRST 2-Way Crystal Filter Radio to Guarantee Lifetime Receiver Selectivity Uses HERMES CRYSTAL FILTERS

AEROTRON, 600 Series, Two-way VHF-FM Radio Communications Equipment



A portion of schematic diagram for AEROTRON 600 Series Receiver showing Hermes 10.7 Mc Crystal Filter at First Mixer.

Hermes Crystal Filter, Model 10 MB, measures 2¾" long x 1" wide x 1 1/32" high.

The AEROTRON, Model 600 Series, is the first commercially available two-way VHF-FM Mobile Radio Equipment to use a high frequency crystal filter to guarantee Receiver selectivity for the life of the equipment. This equipment is designed by Aeronautical Electronics, Inc. of Raleigh, North Carolina, for the new "split channel" frequency allocations where exceptional frequency stability and selectivity are imperative. The use of a Hermes Crystal Filter at the highest intermediate frequency eliminates any desensitization from very strong, adjacent channel stations and offers a very flat response throughout the bandpass of the filter.

Hermes crystal filters were selected because of their superior performance, small size, and immediate availablity. Close cooperation between the engineering departments of the two companies contributed to the rapid development of this new Mobile Radio Equipment. Receiver characteristics include: *Frequency Stability:* ±0.0005% over −40 to +75°C; *Sensitivity:* 0.6 microvolt or less for 20 db quieting; *Selectivity:* ±7.5 kc at 6 db down; *Modulation Acceptance:* ±½ db throughout bandpass range of ±6 kc.

Whether your selectivity problems are in transmission or reception, AM or FM, mobile or fixed equipment, you can call on Hermes engineering specialists to assist you in the design of your circuitry and in the selection of filter characteristics best suited to your needs. *Write for Crystal Filter Bulletin.*

A limited number of opportunities are available to experienced circuit designers. Send résumé to Dr. D. I. Kosowsky.

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M.I.T.'s Humanities Course

(Concluded from page 23)

Course XXI is not a short cut to becoming a scientist or a magic way of becoming a humanist. Its aim is to use the resources of a great center of scientific and technological knowledge in terms of the learning and culture of the past and present of our world. This aim, which should bring the study and understanding of science, technology, and the humanities together, demands the arduous discipline common to every field of study at M.I.T.

Where Are They Now?

Of the 10 members of the Class of 1958 who took Course XXI, three now are teaching in preparatory or high schools, two are in graduate work in science and engineering (one a Rhodes scholar), two are in medical school, one in graduate work in the philosophy of science, and one in the Air Force.

The Class of 1959 has 18 Course XXI graduates, of whom there are four now in business, four in graduate work in English literature, three in the armed services, two in scientific editing and writing, one in law school, one in medical school, and one in graduate work in engineering at M.I.T.

It is clear that the range is wide and that the program is unique in American education today. Course XXI can begin to introduce a student to a professional life as a scientist or engineer or to a variety of professions or to public service which demands both a knowledge of the science and technology of the modern world and an understanding of its civilization.

Behind the curriculum is a philosophy of education which, in stressing the importance of individual development, flexibility, intellectual discipline and experiment, aims to break down the barriers — sometimes real and sometimes imagined — which have often separated scientists and humanists. Course XXI, in short, offers the kind of education which has become an increasingly important prerequisite for men who are to exercise responsibility and judgment in the affairs of our society and who are to see all human activities as part of their own lives as citizens and professional people.

FAMOUS HASPEL

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Haspel Sir Perior presents the most direct route to a cool, convenient, carefree summer. No lightweight clothing we know of shakes off wrinkles like a Haspel to keep a crisp neat appearance even in the muggiest weather. These are the original "no-care" suits. A washing machine keeps them clean. Drip-drying keeps them pressed. An occasional ironing touch-up is all that's ever needed.

75% Dacron Polyester—25% Cotton

39.95

Sir Perior Suits

The fabric from which this handsome suit is styled is a very special blend of 67% Dacron (polyester) 33% Cotton . . . and light as air. As for care, it requires none. It resists wrinkles, stays fresh and crisp through heat and humidity. Wash it by machine then let it drip-dry. If you wish, give it a once-in-awhile touch-up.

39.95

The New Dacron-Orlon

The blend is new . . . the fashion is too . . . our half-Dacron, half-Orlon suit by Haspel. Equal helpings of Dacron and Orlon are deftly and wonderfully combined to give this fabric a silky look and feel. Haspel styles it with great flair into the newest automatic wash and wear fashion of the season. Stays crisp and fresh in the most humid weather. It can be washed and dried automatically . . . ready to wear, with little or no ironing needed.

45.00

All-Cotton Seersucker

On the scene for many a summer and still one of the best-liked summer suits around, all cotton seersucker by Haspel. And only Haspel styles seersucker like this . . . gives it that sophisticated touch that has made it a traditional favorite. Here, the original smart summer suit that always looks cool and inviting, even in the most sweltering weather. Washes like a handkerchief, requires a minimum of ironing.

32.50

Jackets 25.00

Institute Yesteryears

25 Years Ago . . .

ON MAY 11, 1935, the Institute mourned the passing of Alfred Edgar Burton, its first Dean of Students from 1902 until his retirement as an Emeritus Professor in 1921. Born at Portland, Maine, on March 24, 1857, he was graduated as a member of the Class of 1878 at Bowdoin College, and after serving as a topographer with the United States Coast and Geodetic Survey, came to M.I.T. in 1882, becoming Professor of Topographical Engineering in 1896.

Among the spontaneous tributes prompted by his retirement in 1921, that of The Review's editor, Professor Robert E. Rogers, most charmingly and adequately portrayed the qualities which made Dean Burton "one of the great men in Technology's history." He wrote in part:

"And withal our Dean never lost his dignity, he was never razzed in an unkindly spirit, he never condescended, was never aloof, or petulant; it never seemed an effort, though often it must have been, to be so continually with the men; to understand them, to separate the essential from the inessential, to praise or reprove the essential and let the inessential go as of no importance.

"It never seemed an effort, as it surely must have been, in the days before the medical service was instituted, to keep track of the boys who were sick and lonely, to get doctors for them and to visit them; at how great a sacrifice of time and strength nobody knows, to find the boys who were badly lodged or in the wrong neighborhoods or the wrong company; to keep track of the foreign boys who so often were entirely on their own responsibility in a strange city, and to try to give them something of our American home life and companionship. It never seemed a task to this man of splendid strength, who wore his years so lightly, who kept his temper, and his courage and enthusiasm, and, above all, his humor, so unquenchably alive. . . .

"He was an artist using the tools of science, and, later, the tools of human relationships. He loved to create in art; he loved the masquerades and merrymakings at his home, his little marionette theater he spent so much care and pains upon; he loved, apparently, to dress up and see others play a part; he loved to see people come out of their shells and create, for their own pleasure and happiness. And in that he was the finest artist of all. Lots of people can teach science and engineering and things; lots of people can be good administrators and efficient deans. But the man who is an artist in an inartistic job is one in a million. And that is Dean Burton . . . a creative artist in teaching men how to live."

50 Years Ago . . .

AT A MEETING of the Alumni Council, it was announced that the Executive Committee of the Corporation had unanimously approved the Council's recommendation that a Congress of Technology be held in connection with the celebration of the 50th anniversary of the granting of the Institute's charter.

Also, by a further communication, President Richard C. Maclaurin acknowledged receipt of a report by the Council's committee on aëronautics, but stated that "before definite steps could be taken to follow the suggestions of the Council, expert advice is to be obtained by the President of the Institute. The Executive Committee is of the opinion that now is the time to establish work in aëronautics, but also believes heartily in the suggestion that the work be of the character of graduate research rather than a regular undergraduate Course. Information has been sought from foreign universities where already some investigations in aëronautics have been made."

75 Years Ago . . .

THE SOPHOMORE Class of 1887, at a meeting held May 16, 1885, "voted to issue an Institute Annual next year." Thus was started a chain of activity which culminated in the first edition of *Technique*.

¶To the editor of *The Tech* it seemed appropriate to issue words of caution for, wrote he, "Already the shadow of the coming annuals has begun to darken the bright and hilarious days of class-dinners, Senior balls, and Glee Club receptions. The weary Seniors are grinding out their theses; the Junior begins to burn the midnight oil over his applied mechanics;

(Concluded on page 54)

Vannevar Bush Room, M. I. T.
Translucent ceiling conceals wiring, lighting, air-conditioning in this handsome new addition.
Electrical installation by

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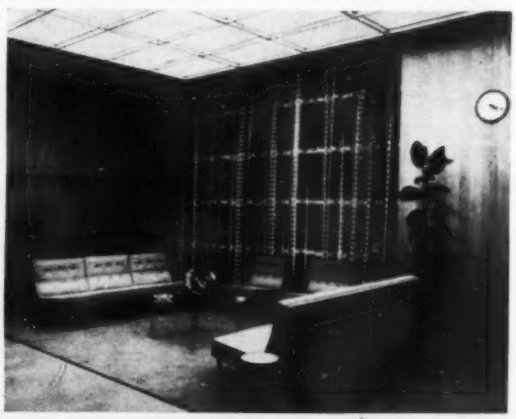
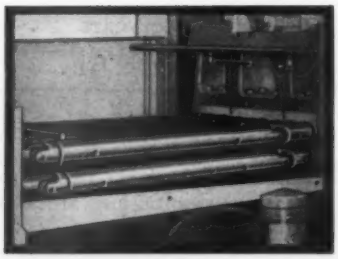


How Curtis solved a close center-to-center problem



The close center-to-center spacing of these drive spindles on a Sutton-Maust Precision Backed-up Roller Leveler created a tough problem for its manufacturer. He needed a universal joint strong enough to stand up under heavy rolling mill conditions, yet small enough to operate at such close quarters.

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Institute Yesteryears

(Continued from page 52)

thoughts of the grand ordeal in physics intrude, like nightmares, into Sophomoric dreams; and chemical equations disturb the sweet slumbers of the Freshmen.

"That examinations are an evil, all alike agree."

¶ The editor equally viewed with alarm the "lack of interest in athletics at the Institute." But this, he believed, "although much to be deplored as it is, can scarcely be considered unnatural. To be sure, a gymnasium is open to the students, in which they may practice if they wish; but here the Faculty's interest in the physical well-being of the student ceases. They offer no inducement to the students to take regular healthy exercise.

"The gymnasium is open; but it is too open, and at the same time not open enough. Anyone can go in, and if he sees fit, or ignorantly, he may do himself any amount of harm; there is no instructor to tell him what he needs, or restrain him from what he does not need. On the other hand, the gymnasium is practically closed to those who feel their inability to judge of their own requirements, because of their inexperience in things of the sort."

Syracuse Regatta Will Be June 18

M.I.T. will send three crews this year to the annual Intercollegiate Rowing Association Regatta on Onondaga Lake, near Syracuse, N.Y., on June 18. IRA tickets may be purchased by contacting the M.I.T. Athletic Department.

New Books from the **Technology Press**

Word and Object

By Willard Van Orman Quine

A treatise on language, its acquisition, its translation, its referential apparatus, and the objects to which it refers, with reflections on logic and ontology that take account of the nature of verbal behaviour. 294 p. $5.50

Fluid Power Control

Edited by J. F. Blackburn, G. Reethof, and J. L. Shearer

A basic mathematical and experimental analysis of fluid-power devices, with abundant design information on hydraulic and pneumatic systems and components. Based on the work of the fluid-power group of the M.I.T. Dynamic Analysis and Control Laboratory. 710 p., illus. $17.50

The American Civil Engineer: Origins and Conflict

By Daniel H. Calhoun

A study of the development of the profession of civil engineering in the canal- and railroad-building years of early 19th-century America. 295 p. $5.50

The Internal Combustion Engine in Theory and Practice

By C. Fayette Taylor

The first volume of a two-volume definitive work on the internal combustion engine. Full design and performance data in many charts, curves, and tables. Illustrative examples. 574 p., illus. $16.00

Hydromagnetic Channel Flows

By Lawson P. Harris

Analyses of three kinds of flow of viscous, incompressible, electrically conducting fluids in high-aspect-ratio rectangular channels subjected to transverse magnetic fields: turbulent flow in the presence of a d-c magnetic field, and both laminar and turbulent induction-driven flows, 90 p., illus. $2.75

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From left, Bill Ackerman, C.L.U., New England Life, R. F. Denton, Jr., and H. W. Jamieson, prominent California businessmen.

New England Life's Bill Ackerman makes a business of serving California businessmen

Bill Ackerman works with men with ideas and companies with potential. For example, Bill handles the business life insurance for organizations in which H. W. Jamieson and R. F. Denton, Jr., have an interest.

Bill gets a deep sense of satisfaction from the knowledge that he's contributed to the growth and strength of young businesses. Since joining New England Life in 1946, he's seen many of the men he's insured become successful executives. And Bill, himself, is a success. He's a life member of our own Leaders Association and of the top national organization, the Million Dollar Round Table.

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For more information, write Vice President John Barker, 501 Boylston Street, Boston 17, Mass.

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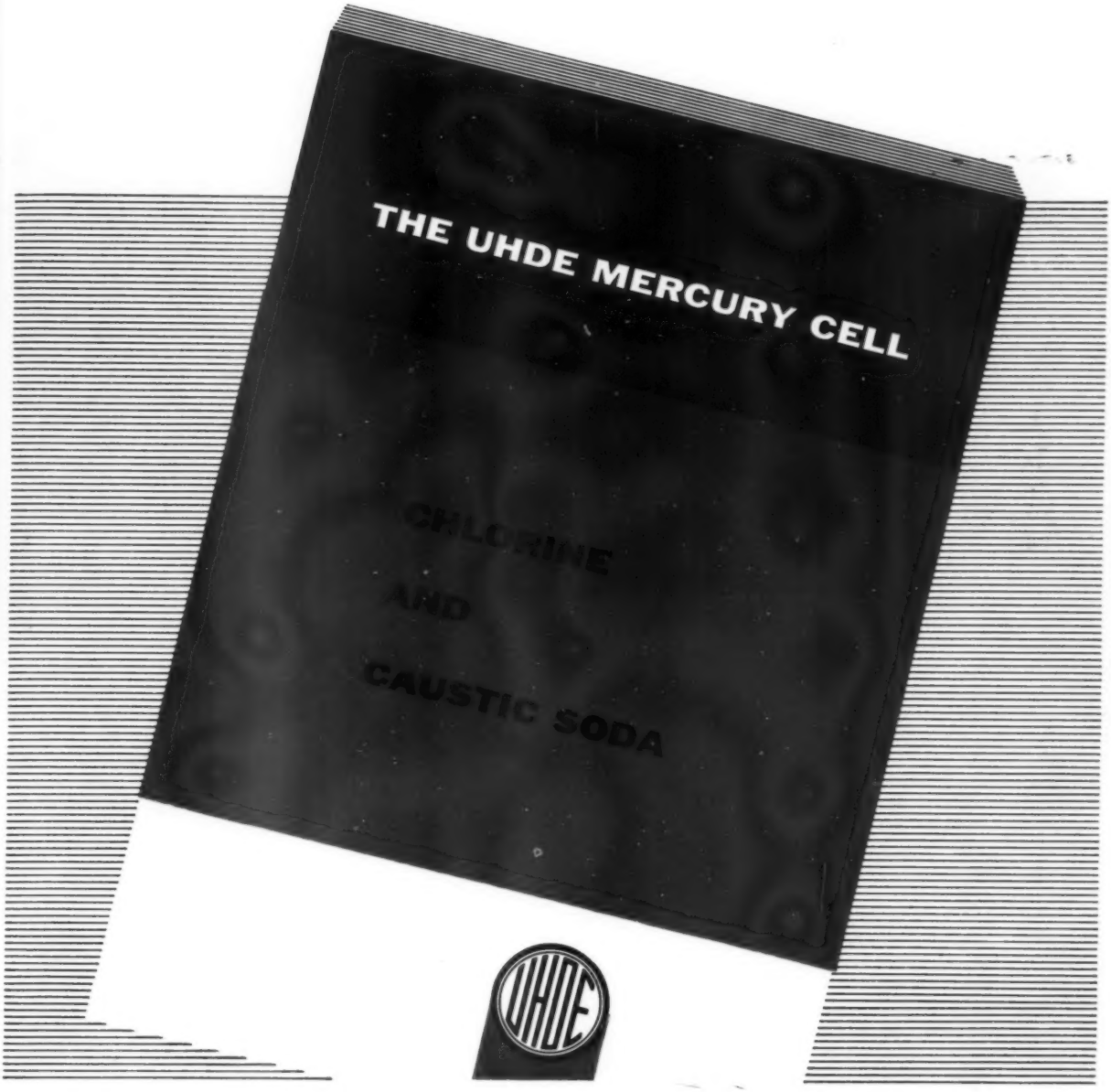

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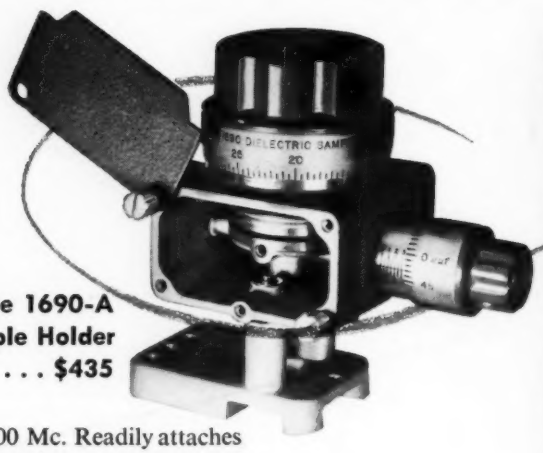

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From 30c to 100 kc

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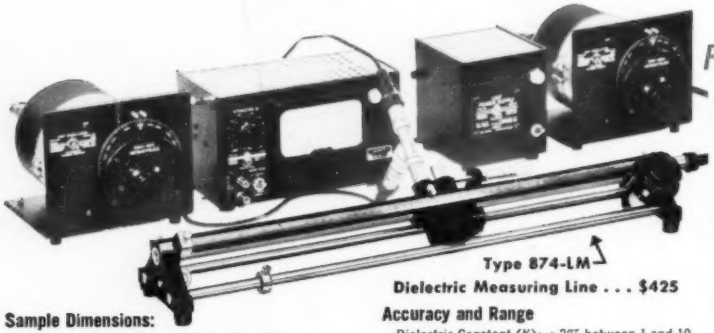
A complete system for measuring capacitance from 100 $\mu\mu$f to 1.15 μf at 1 kc; to 1150 $\mu\mu$f at frequencies to 100 kc. Will measure capacitance as small as 0.1 $\mu\mu$f using substitution methods. Accuracy, $\pm 0.1\%$ using direct method, $\pm 0.2\%$ for substitution method. Dissipation-factor range, 0.00002 to 0.56; accuracy, $\pm 2\%$. Assembly may also be used with liquid-dielectric cells.

At 1 Mc

Type 1610-AH Capacitance Measuring Assembly...$1035

Can be used from 0.1 to 5 Mc with external generators. Range: direct method, 100 to 1150 $\mu\mu$f; substitution method, 0.1 to 1050 $\mu\mu$f. Accuracy and D range same as 1610-A2.



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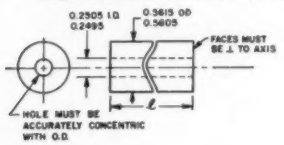
Sample Dimensions:

Length dependent upon K and frequency



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Dielectric Constant (K): $\pm 2\%$ between 1 and 10
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Maximum: 5000 Mc or $\frac{9000}{\sqrt{K}}$ whichever is smaller

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